Proceedings of the Twenty-fourth Indian Science Congress

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PSYCHO-PHYSICS AND MENTAL TESTS.

THEORETICAL PSYCHOLOGY.

INTELLIGENCE AND 'FACTOR' PSYCHOLOGY.

EDUCATIONAL PSYCHOLOGY.

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PROCEEDINGS OF THE TWENTY-FOURTH INDIAN SCIENCE CONGRESS.

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The Twenty-fourth meeting of the Indian Science Congress Association was held at Hyderabad, Deccan, from January 2nd to 8th, 1937.

The inaugural meeting was held on Saturday, January 2nd, 1937 at 10-30 A.M. in the Town Hall, Public Gardens, Hyderabad, in the presence of the Rt. Hon'ble Sir Akbar Hydari. The Hon'ble Nawab Mahdi Yar Jung Bahadur, Political and Educational Member, Vice-Chancellor, Osmania University, Chairman of the Reception Committee, welcomed the delegates in a speech and requested the Rt. Hon'ble Sir Akbar Hydari to open the Congress. Sir Akbar Hydari opened the Congress with a speech and then the President of the Congress, Rao Bahadur T. S. Venkatraman, B.A., I.A.S., F.N.I., delivered his address. Professor J. N. Mukherjee, General Secretary, thanked the Rt. Hon'ble Sir Akbar Hydari for the trouble he had taken in opening the Congress.

THE SECTIONAL PRESIDENTIAL ADDRESSES WERE DELIVERED AS FOLLOWS :—

SUNDAY, *3rd January*, 9-30 A.M., Agriculture ; 10-30 A.M., Medical and Veterinary Research ; 11-30 A.M., Geology and Geography.

MONDAY, *4th January*, 9-30 A.M., Physiology ; 10-30 A.M., Psychology ; 11-30 A.M., Mathematics and Physics.

TUESDAY, *5th January*, 9-30 A.M., Zoology ; 10-30 A.M., Chemistry.

WEDNESDAY, *6th January*, 10-30 A.M., Botany.

THURSDAY, *7th January*, 9-30 A.M., Anthropology.

SYMPOSIA AND JOINT MEETINGS OF SECTIONS WERE HELD AS FOLLOWS :—

MONDAY, *4th January*, 10-30 A.M.–1 P.M., Joint Meeting of the Sections of Medical and Veterinary Research, Physiology, Agriculture and Chemistry to discuss 'Nutrition in Relation to Crops, Human Beings and Farm Live-stock'; 11 A.M. to 12-30 P.M., Discussion on 'The Age of the Deccan Trap', Section of Geology and Geography.

TUESDAY, *5th January*, 11-30 A.M.–12-30 P.M., (1) Discussion on 'Glycosuria', Section of Physiology ; (2) Discussion on 'The Teaching of Chemical Technology', Section of Chemistry ; 11-30 A.M.–1 P.M., Joint Meeting of the

Sections of Agriculture, Geology and Geography to discuss 'The Need for a Soil Survey of India'.

WEDNESDAY, *6th January*, 2 P.M.–3-30 P.M., Joint Meeting of the Sections of Psychology and Physiology to discuss 'Conditioned Reflexes'.

THURSDAY, *7th January*, 1-30 P.M.–4-30 P.M., Joint Meeting of the Sections of Geology and Geography, Zoology and Botany to discuss 'Wegener's Theory of Continental Drift'.

POPULAR LECTURES WERE DELIVERED AS FOLLOWS :—

SATURDAY, *2nd January*, 6-30 P.M., 'Nepal the Land of Mystery' by Professor S. P. Agharkar, M.A., Ph.D., F.L.S., F.N.I.

SUNDAY, *3rd January*, 6-30 P.M., 'Modern Alchemy: Artificial Synthesis of Elements' by Professor S. N. Bose, M.Sc., F.N.I.

MONDAY, *4th January*, 6-30 P.M., 'Racial Types in the Population of India' by Dr. B. S. Guha, M.A., Ph.D., F.N.I.

TUESDAY, *5th January*, 6-30 P.M., 'Earthquakes in India' by W. D. West, Esq., M.A., F.N.I.

THE FOLLOWING FUNCTIONS AND ENTERTAINMENTS WERE HELD IN HONOUR OF THE MEMBERS OF THE INDIAN SCIENCE CONGRESS :—

SUNDAY, *3rd January*, 4-30 P.M., 'At Home' at Mahdi Manzil, Jubilee Hills by Nawab Mahdi Yar Jung Bahadur, Vice-Chancellor, Osmania University.

MONDAY, *4th January*, 4-30 P.M., 'At Home' at Osman Sagar by the Reception Committee.

WEDNESDAY, *6th January*, 4-30 P.M., 'At Home' by Nawab Mahdi Yar Jung Bahadur, Political and Educational Member, at River Gardens; 9-30 P.M., Urdu Drama, 'Malan', Excelsior Theatre.

THURSDAY, *7th January*, 8 P.M., Banquet by Reception Committee.

THE FOLLOWING VISITS AND EXCURSIONS WERE ARRANGED FOR MEMBERS OF THE INDIAN SCIENCE CONGRESS ASSOCIATION :—

SATURDAY, *2nd January*, 5 P.M., Visit to the Osmania University Buildings.

SUNDAY, *3rd January*, 1-30 P.M., Excursion: Section of Geology and Geography; 2 P.M.–4 P.M., Excursions

to the Cottage Industries Institute, The Industrial Laboratory, Agricultural, Poultry and Dairy Farms.

MONDAY, *4th January*, 2. P.M.–4 P.M., Excursions to the Pre-historic Graves, Golconda and Osman Sagar.

WEDNESDAY, *6th January*, 2 P.M.–4 P.M., Excursions to Mint, Mint Workshops and Osmania Technical Institute or Nizamia Observatory.

FRIDAY, *8th January*, Whole-day Excursions to Bidar, Dichpally and Nizam Sagar.

THE SECTIONAL COMMITTEES met at 2 P.M. on Saturday, 2nd January, 1937.

THE COUNCIL met at 3-30 P.M. on Saturday, 2nd January, 1937.

THE EXECUTIVE COMMITTEE met at 9-15 P.M. on Sunday, 3rd January, 1937.

THE GENERAL COMMITTEE met at 2 P.M. on Tuesday, 5th January, 1937.

Opening Proceedings.

The Twenty-fourth Session of the Indian Science Congress was opened on Saturday, January 2nd, 1937 at 10-30 A.M. by the Rt. Hon'ble Sir Akbar Hydari, Kt., P.C., in the Town Hall, Public Gardens, Hyderabad (Deccan), in the presence of a large gathering of delegates and visitors.

The Rt. Hon'ble Sir Akbar Hydari, addressed the meeting as follows :—

"LADIES AND GENTLEMEN :

I cannot make a more felicitous beginning than by reading out the very gracious message sent by His Exalted Highness the Nizam of Hyderabad and Berar to the President and Members of the 24th Session of the Indian Science Congress.

The message is as follows :—

'I am rejoiced to hear that in response to the invitation extended by my Osmania University, you are holding the 24th session of the Indian Science Congress in the capital city of my Dominions. As the Prince of Berar, owing to his absence from Hyderabad, cannot have the pleasure of opening the Congress and welcoming you all personally, I send this message to bid you Godspeed in your deliberations.

The growing realisation by Indian Universities of the need for providing adequate facilities for research in all branches of science is indeed a welcome sign. Your Congress may take a legitimate pride in what it has done in recent years to foster the spirit of scientific inquiry and research in India. Though comparatively young, the Osmania University has been preparing to make its contribution to research in science. It is my earnest desire that it should co-operate with other Indian Universities in preparing the way for a scientific renaissance which will contribute to the material progress and prosperity of India and at the same time secure for her an honoured place in the ranks of nations who lead in enlightenment and culture.

I wish your Conference success in its labours.'

Ladies and Gentlemen, this is the first occasion on which the Indian Science Congress is meeting in this great historic city. Happily, your first visit coincides with the year when we are celebrating the five and twenty years of His Exalted Highness' reign. During your stay you will have occasion to see for yourselves the signs of activity and progress that are visible in every direction. For what the State is today, and for this

all-round progress, we Hyderabadis are indebted to His Exalted Highness and to the care, devotion and zeal with which he has carried out his noble stewardship of the State. Let us, on this occasion, while sending him our respectful thanks for his very gracious message, also tender to him our sincere congratulations for the Jubilee Year which started yesterday and our heartfelt prayers that he may live happily and continue for many, many years to preside over the destinies of his people.

Hyderabad has for long been the centre of a great culture and noble traditions. Many races have met here and, down the ages, a harmonious blending of their diversities has resulted in a common Deccani culture of our own of which we are justly proud. It has been the task and achievement of the Asafiah Dynasty to foster and promote the process whereby this synthesis of Dravidian and Aryan, Hindu and Moslem cultures has been effected, and His Exalted Highness has enlarged its scope so as to include in it the best of Western and Eastern life, manners and thought. You will find this spirit working in every sphere of our activity and we consider the result to be a real contribution to the ideal of a united and regenerated India.

The University which welcomes you today bears testimony to that spirit. Scholars may here study and acquire the fruits of the accumulated wisdom and research of the East and the West in one of our own languages which serves effectively to express, as our experience has shown, the most abstruse thought in science or in philosophy. We are convinced that the decision to adopt Hindustani as the medium of instruction in our University is a great step forward in the direction of national unity and an All-India synthesis. That decision is the corner-stone of our educational policy and, fortified by experience, stands more irrevocable today than it did at any previous time.

Here, in this University, we set the highest value on scientific inquiry. We recognise that no nation or individual can afford to ignore the study of science and that material progress depends in large measure on the results of scientific inquiry. Although we in India have entered this field of modern endeavour after a considerable lapse of time, it is satisfactory to note that our Universities and Research institutions have, despite difficulties, produced a standard of excellence and originality of which we have reason to be proud. And I am sure that, with the ever-increasing recognition by the average Indian of the value of science, an atmosphere conducive to creative work in the realm of science will soon come into being.

But it is not only nor mainly for its directly material and tangible results that I set such value on science. While critics of the materialistic conception of life and of scientific achievement may minimise the sum-total of their efforts on human happiness, who shall deny the immense service rendered by Science in liberating mankind from the trammels of blind superstition

and barren dogma and in generating a higher, better and more correct sense of values? Besides there is value in scientific inquiry as such. The assiduous and patient collation of data, of facts and figures, the training in observation and method and the spirit of verification which induces precision, veracity, balanced and fair judgment, are of superlative value to the Administrator. I would specially refer here to the claim of one Science, the Science of Statistics, the value of which was impressed on my mind many, many years ago by an acquaintance with the publications of the United States Government and Universities, and above all, by that classic on statistics, the Grammar of Science, by Karl Pearson who passed away in the course of the last 12 months. Those in India who have to deal with the problems of administration feel constantly the disadvantages they labour under by the absence of statistical data, scientifically recorded, checked and treated relating to every sphere of sociological activity with which an administrator has to deal and without which it is impossible to have a sufficiently accurate and comprehensive picture of a particular problem.

At the same time this very sense of values requires that the growth of the human intellect should not be at the expense of other human faculties. We believe that the parallel development of our moral and spiritual faculties and of the sense of appreciation of the sublime in nature and the beautiful in art is necessary for the development of an individual to the full stature of a man. In a distracted world, a nation so developed may prove a valuable asset in directing energies to their true aim.

These are the ideals on which we are building, and for you, coming as you do from all parts of India, the process of reconstruction is certain to be of some interest. Apart from it, Hyderabad will be of interest to you also in other directions. Its political and cultural history, its ancient geological character, its beautiful archæological monuments, its ethnographical features, its mineral resources, its rich field for the development of industries, are subjects deserving of observation and study. We are almost a compact world of our own and we love it and are rightly jealous of its privilege and place. And it is in the fitness of things that Hyderabad which has in the past been the cradle and the refuge of so many men of letters and whose Rulers have always been such great patrons of the Arts and the Sciences, should today welcome the eminent scientists of all India on her soil.

And now I leave you to your labours. I hope that your deliberations will be crowned with success and that when you return you will be able to look back upon the days spent here as days of fruitful labour and happy memories. We shall always remember your visit with pleasure and satisfaction and if, at any time in the future, you would desire to hold another Session of your Congress here, I need hardly assure you that you will again be as cordially welcomed."

The Chairman of the Local Reception Committee, Nawab Mahdi Yar Jung Bahadur welcomed the delegates and visitors in a speech as follows :—

"MR. PRESIDENT AND MEMBERS OF THE INDIAN SCIENCE CONGRESS, LADIES AND GENTLEMEN,

Allow me, sir, on behalf of the Osmania University and of the people of these Dominions, to extend to you and to the members of the Science Congress our most hearty welcome. All of us here in Hyderabad appreciate highly the honour you have done us in accepting our invitation, and we wish to assure you that you have our willing co-operation and goodwill in the great task you have set yourselves of scientific research and inquiry ; at the same time we wish to express our admiration for all you have done towards fostering and promoting research and infusing the scientific spirit in our people.

Sir Akbar Hydari has already alluded to the happy coincidence whereby your visit to this State occurs at a time when we are about to celebrate the Silver Jubilee of His Exalted Highness. He has further referred to the manner in which these Dominions have benefited by His Exalted Highness' progressive and enlightened rule. A living symbol of the ideals that have inspired him and his Government may be seen in the Osmania University which, though still young, is well past the stage of experiment. We have succeeded in effectively adopting simple Hindustani, the most widely spoken and the most commonly understood of all Indian vernaculars, as the medium of instruction thus giving our University an All-India character rather than a narrow, provincial one. And it is a tribute to the wonderful adaptability of Hindustani, its expressiveness and the richness of its vocabulary, that no matter what the subject, whether Science or Mathematics, Politics, Law or Philosophy, this medium has proved more than adequate for its clear exposition. Thus the profoundest thought has become all the more easily intelligible to our students through the adoption of the medium of a language of the country. One of the results of this has been to give a stimulus to originality of thought. This in its turn has created a spirit which is germane to the pursuit of scientific inquiry, and in fact science of all kinds has become a popular subject with our students. As, however, the knowledge of a Western language is essential to enable one to keep pace with modern progress, great stress is laid in the Osmania University on the study of English, which is a compulsory subject, while there are also arrangements for teaching other European languages. In these circumstances there is no reason to doubt that the Osmania University will soon be able, through the efforts of its Professors and the labours of its scholars to reach standards in creative thought and scientific research second to none in India.

Since the dawn of creation man, endued with an intelligence superior to that of other animals, has been a being who could cogitate and reason. From the earliest stages of his evolution, he must have examined with intelligent curiosity the material world around him, impelled as he must have been by the necessity for existence or for protection and defence against his enemies. These bare needs satisfied, he must, at a later stage, have been led partly by an innate curiosity or thirst for knowledge, and partly perhaps by a lust for conquest, or some other ambition, to explore further the material world and turn his discoveries to his advantage. He must have gazed at the firmament at first with awe and superstition, and then with intelligent wonderment which must have gradually led to an accurate observation of the movements of the heavenly bodies. Similarly, natural phenomena, viewed at first with superstitious dread as signs and portents, must have eventually yielded up their secrets to an intelligent inquiry into their causation. Thus Natural Science may be said to have had its birth from the very moment man subjected matter to intelligent observation. In this way, some of our principal sciences, and the arts dependent on them, have their roots in the remote past, and many of the discoveries in Astronomy, Mathematics, and even Physics (such as the famous Archimedes' principle) are of ancient origin. As the dawning light of reason dispelled the clouds of darkness and superstition, the ancient sciences assumed by degrees their modern shape. Thus the old Astrology gave place to modern Astronomy while the ancient Alchemy paved the way for the modern science of Chemistry. What with the invention of modern instruments of precision and the development of scientific methods of observation, which made research easier, one discovery led to another, so that in the last 50 years, the progress of science has been amazing in rapidity. It has profoundly influenced the social and economic life of nations and materially changed their outlook. This revolution is nowhere more apparent than in sciences applied to arts and industries, and to the annihilation of time and space effected by the rapidity of transport and communication. You can whisper to London now or fly to Australia. Vision, carried beyond its natural limitations by artificial aid, is now enabled by means of television, to perceive the features of a person who sends you a wireless verbal message from a considerable distance; and yet within living memory, not so long ago, there was a time when there was no wireless, no motor cars and no aviation. I remember that professors of Physics used to scoff at the idea of a heavier-than-air machine being able to fly.

This enormous output of science to which all the preceding ages have contributed their share, and the last half century most of all, is so stupendous in bulk and so wide and varied in its sphere, that it is impossible, indeed hopeless, for the mind

of one man to grasp or encompass all that has been said or written about any one science, let alone the whole of them. This is, therefore, the age of specialisation. Time was when, in ancient days, a scholar was supposed to study all the 'Sciences' as they existed, in order to complete his education. Today one small aspect of one little branch of a science demands the patient labour and research of a lifetime. The field is so vast, and the work required to be done so varied and multifarious that division of labour is necessary as well as co-ordination of effort for any advance to be made; and it is just for the purpose of such division of labour, and in order that our efforts may be co-ordinated, that Conferences like the present one are of great value. It is necessary to receive the report of the vanguard of this advancing army of scientists as to the new ground explored and the latest conquests made, the new vistas that have been opened up giving a glimpse of other fields beyond, where fresh conquests are to be made. What are the furthest limits to which the standard bearers of this advance have carried the flag? What are the plans for further advance, and how should it be organised? What work is to be allotted, and to whom, in this grand collaboration? And what are the materials that can be placed at one's disposal as the result of the latest discoveries made by others? It is in order to decide these questions and to co-ordinate their labours in some such fashion as I have indicated, and to concert measures as well as to compare notes and take counsel with each other, that the members of this Conference have instituted their annual meetings; and it is a matter of pride and gratification for India that some of the pioneers in this work, at once the noblest and the most intellectual that man can undertake, are counted among her sons.

There is a free-masonry among scientists—a universal brotherhood of fellow-workers all over the world. For this intellectual fraternity knows no limits of nationality, land or religion. The discovery made in one country one day becomes the common property the next day of all the world. While intensive specialisation may narrow the outlook for a man, there is this to be said on the other side that few men are apt to be less provincial or parochial than the man of science.

The blessings that science brings in its train—material comfort, treatment of disease, safe and speedy travel, instantaneous communication—are too obvious to require mention. But some people who have a way of always looking at the darker aspect of things, pretend to see in this advancement of science only a potential menace to humanity owing to the havoc and destruction modern science can cause in War. To such I would say that it is not science itself that is to blame for this but those who make a perverted use of it for purposes of destruction. Even so, the good that it can do so far out-balances the evil,

that the service of humanity alone would be sufficient justification for its pursuit.

It was commonly believed at one time that a conflict existed between science and religion. No one now holds that belief. For if truth is the foundation of all ethics, as it undoubtedly is, what edifice could rest on a better foundation than that built up by science which is based on truth; and as religion also presents to us the truth, though as a matter of belief or faith, and not by arriving at it through a process of reasoning, there can be no conflict between the two in their aim though there is a marked contrast in the method employed. As for being dogmatic, one recollects that some scientists, specially in the last century, were just as much the slaves of theories (now disproved) as the narrowest minded of ecclesiastics. They would not preserve an open mind nor bear to have their pet doctrines demolished. Luckily, that is not the attitude of modern scientists today even towards those theories which have the greatest weight of scientific opinion in their support. The truly scientific mind is one which has no bias but is open to conviction by the production of sufficient proof.

Gentlemen, I have referred to the mighty bulk of the work that has been done in the way of scientific research and discovery. Yet what remains to be discovered is far greater than what has been discovered, quite apart from that which is unknowable and which no human knowledge can ever encompass. In most fields of scientific investigation and research, not even the fringe of the subject has been touched. But, to quote the words of a popular thinker: 'The final conclusion is that we know very little, and yet it is astonishing that we know so much, and still more astonishing that so little knowledge can give us so much power.'

We have just heard the gracious message of His Exalted Highness who has wished you Godspeed and success in your labours. In concluding, therefore, this brief address, I feel that I cannot do better than to reiterate that wish with the added hope that great and lasting good may result from your conferences."

Presidential Address.

Congress President :—RAO BAHADUR T. S. VENKATRAMAN, B.A., I.A.S., F.N.I.

THE INDIAN VILLAGE—ITS PAST, PRESENT AND FUTURE

CONTENTS.

I. Introduction.

I take it no apology is needed in these days for talking about any aspect of 'village and village life'. The city and the town which were holding a complete thraldom over the Public mind all these years are losing their glamour somewhat in spite of their admittedly alluring attractions; and the 'village' would appear to be getting increasing recognition, particularly in our country and in recent times.

I propose to speak to you to-night under the caption 'The Indian Village—Its past, present and future'. You might perhaps question my claim to speak on this subject as all my official life and thought for the last quarter of a century has been linked up almost entirely with sugarcane. But this very work has often taken me to the countryside in various parts of India and my contact with the Indian village has been fairly intimate. While at my special work I had perforce to witness the pleasures and tragedies of the villager and watch the changes that are steadily coming over the village. Secondly, most of us—in this agricultural land of ours—have come from villages and are in fair contact with village life either directly or through our kith and kin.

One easily noticed change in the village is the migration of the villagers to the town. The richer of the villagers show a tendency to shift themselves to the nearest town or city for the education of their children, for better medical help or for the characteristic amenities associated with urban life. Secondly, the more intellectual of the younger generation, who first migrate to the towns for their studies or to seek employment, do not generally return to the village, but settle in some town which they find more congenial for the full scope of their talents. If they do pay a visit to the village it is either to see an old relative who is too conservative to move to the town or in connection with some matter which renders their presence in the village unavoidable. Such visits are made of as short duration as possible and they get back to the town with almost a sense of relief.

II. Position of India with reference to Space and Time.

But before getting into the subject proper it is necessary to record here a few general observations on the position of our country with regard to both space and time view-points. With China, Japan and the South-Eastern islands, India is situated in a comparatively densely populated area of the globe—about half the population of the world being crowded into a tenth of the Earth's land region. This has had its effects on the type of agriculture practised in the country, the selection of crop for cultivation and the life of the people as a whole.

Secondly, along again with China, India possesses a civilisation and culture which was at least contemporaneous with, if not antecedent to, the civilisations of Egypt, Mesopotamia, Greece, and Rome. After making considerable progress this civilisation has, however, remained in a more or less quiescent and petrified state in our villages for well nigh two to three thousand years, little influenced by the great progress made by the West during the latter part of the same period. It is only within comparatively recent times that the Western civilisation has come to spread into and influence the countryside. In more senses than one the Indian town represents the dynamic West with all the vigour of youth and the village the comparatively quiescent East. Certain of the problems of the village to be discussed hereafter will be found traceable to the inevitable contact between the two.

III. Aryan Colonisation of India and Types of Villages.

In early times there were two chief passages into India—one on the North-East through Assam and Bengal and the second on the North-West into the Indus region. The Aryans, who entered the country through the North-West route, first occupied the Indus valley and the Punjab plains and later spread to the East of the Jumna as far as the Saraswathi. Subsequently they spread into Bengal and from there would appear to have sent out expeditions by sea to Burma, Ceylon and Java. The Vindhya ranges and the Aravalli hills long acted as an effective barrier against large movements southwards into the Deccan and South India. The country to the South of these ranges remained for long Dravidian, though increasingly influenced by Aryan culture from the North.

The Ryotwari Village.—The new Aryan colonists naturally found plenty of land to settle in and the obvious advantages of group formation brought into being two main types of villages. One was the type similar to what is now termed 'ryotwari' where each family or group of persons took up as much land as they could cultivate depending on the number of cattle and able-bodied men in the unit. Site for the village was chosen at some convenient spot such as the banks of a river or canal or

proximity to other sources of water supply. The persons constituting the village chose a Headman who exercised all powers on behalf of the whole community. This type of village was generally associated with peaceful conditions.

Joint Village.—The other type called 'Joint Village' by Baden Powell was founded by powerful families or clans not necessarily Agriculturists. The government of such villages was by the well-known Panchayat system and occasionally a group of such villages belonged to the same clan or owed some kind of allegiance to the same warrior chieftain in return for the protection they enjoyed at his hands. In these villages the cultivating classes were sometimes in the position of tenants. 'Ryotwari' villages sometimes got converted into 'Joint Villages' through conquest by some warrior chieftain.

IV. The Indian Village in the Past.

Various books, such as the Arthasasthra of Chanakya (before 300 B.C.), the Sukranithi and the Smrithies of Manu as well as inscriptions unearthed in recent times, give us a fairly clear picture of the organisation and government of the village and its institutions in ancient times. The Agamas and the architectural books of South India contain references to the plan and lay-out of the village ; the temple which formed an essential unit in the lay-out influencing and being influenced by the village plan. The villages of South India would appear to have attained a high degree of perfection absolutely unaffected by Aryan influence from the North, so much so that certain authorities hold that some of the Aryan village institutions were copies of the Dravidian. The basic plans as revealed in these villages existing to this day deserve the careful attention of persons engaged in town planning and rural reconstruction. The Manasara (25 A.D.) describes in great detail the lay-out plans of villages, towns and forts as well as the ground plan and elevation of houses, palaces, and buildings for common use like public halls and the theatre.

The Headman.—The Headman was an important officer in village government. His office was hereditary and apparently a vestige of the ancient village chief. He was remunerated by grant of inalienable right to certain lands and later by being allowed to collect and utilise certain taxes from the villagers. He was entitled to collect annually, for instance, two shoes from every shoe-maker, two cloths from the weaver, 13 betel leaves (per day) from the betel leaf vender and a cash moiety from the shop-keeper. He was Gramani or King of the village.

The Village Panchayat.—The Headman was assisted and later on effectively controlled by the village Panchayat. This was a *Council of Elders, not elected,* and more or less self-constituted from the elders of the village who naturally and easily

commanded the respect of the villagers. Justice was dispensed in the village temple and an oath before the local deity was potent in preventing persons from bearing false witness. The Panchayatdars also knew the parties almost personally and were thus able to dispense quicker justice. The Panchayat administered the village funds and thus commanded facilities for catering to village needs. Even after the British came into possession, 22 per cent. of the collection was given back to the villages over portions of the Mahrashtra country.

Autonomous unit.—The village was practically autonomous and once the tax from the village as a whole was paid it had little to do with the Central Government and was not affected by change of dynasties. Later on, however, when during the troublous times following the downfall of the Moghul Empire, wars were carried into the villages as well, they naturally had a share of these troubles. In later times larger political units came into existence having overlordship over groups of villages, though even then each individual village exercised a great deal of self-government in matters pertaining to the village. It is interesting to learn that during Chandragupta's times (320 B.C.) there was a permanent organisation for taking census.

Taxes for common needs.—The village government was carried on in a brotherly informal way, the opinions of the elders carrying much farther than now. Taxes were levied for communal purposes as distinct from those by the Emperor; and there was a common village fund which entertained the village guests, provided for the indigent and arranged for recreations, shows and performances of acrobatic and jugglery feats. The temple, the village tank, the guest house, as well as other public utility concerns had a claim on this common fund. The central government helped in cases where works of common utility were beyond the capacities of the village. This help was given either by the waiving of certain imperial taxes or by contributions in kind. The tax was sometimes levied in the form of manual labour and this is responsible for the huge and elaborate temples found in the south of India, some of them containing priceless treasures of sculptural and other arts. Occasionally also loans were raised by mortgaging the revenues of the village for definite periods.

Village life.—There was not much sanitation in the modern sense of the word and no scavenging. The Arthasasthra lays down a space five cubits wide behind each house apparently as a sanitary lane. Regular sweeping of the village streets was not common and the watchman who was responsible for sanitation thought his duty done when he pulled any carcases out of the streets. Diseases were naturally few on account of the healthier open life and there was no organised medical relief, though there is a record of such measures during Asoka's time. The kitchen store contained most requisites for common ailments and

the elders generally knew a few simple remedies from experience. The science of healing was, however, well advanced for the then conditions and comparatively cheap being based on easily available herbs and both metallic and organic compounds. Certain of its achievements have won occasional admiration from the highly advanced savants of the modern age.

Lay-out of the Village.—The streets were broad. The Arthasasthra prescribes a width of 40 cubits for the main streets which were shaped like the 'back of the tortoise' to facilitate drainage. Each caste which pursued its own profession lived in separate parts of the village and it was surrounded by a common and free grazing ground. The land during the Hindu period did not belong to the King but to the people who occupied it; hence, perhaps, the traditional and great attachment to landed property which still exists.

The professions.—Each village had a class of artisans who were hereditary and being non-cultivating were given definite shares of grain at harvest. In return for this the farmer was entitled to the services of the artisans both for his household and agricultural needs. Whereas professions like that of the carpenter, the smith, the washerman, and the barber were definitely recognised and provided for in the village organisation, the village Teacher was not in this category as literacy was not considered a communal need. Most villages had, however, a school Teacher who was maintained by voluntary presents from the parents of the children attending his school. During marriages and other important occasions, the householder thought it a privilege and honour to feast the Teacher and his whole band of students.

V. The Great Change in the Village.

Self-contained and isolated in olden times.—To realise fully the present conditions of the Indian village and understand its problems it is necessary to briefly notice here the changes that are coming over it and the reasons for that change. The Indian village of ancient times was practically a self-contained, self-governing unit, having but little contact with the outside world. It grew all the crops required to meet all its simple needs and the surplus of good years was stored in the village granaries as a provision against future unfavourable seasons. The people of the village lived like the members of a big family under the accepted leadership of the village elders—the Panchayatdars. Land was plenty, needs few and there was a great deal of contentment. The villager's outlook and knowledge were limited rarely extending beyond the confines of his own village and the villager's life ran an even course from day to day. This had been the condition for well nigh two to three thousand years.

Drawn into world current.—During this same period the West, on the other hand, was rapidly evolving itself from a

condition even more primitive than that of the Indian village to that of modern times. Various inventions and discoveries had enabled man to gain partial mastery over his environment and both time and space had been largely conquered with the result that it is no longer possible nor desirable for any one to be oblivious of outside world events. The world is getting smaller and drawing closer together and an event in one part of the globe soon produces its repercussions all the world over.

Dawn of the spirit of competition.—The increase of population has intensified attempts to augment the available sources of food by opening up new lands where possible and the struggle for existence has brought to the forefront the idea of the 'survival of the fittest'. The spirit of rivalry and competition has sharpened the intellect in certain directions and the rights of the individual as such are getting increasing recognition. The religious impulse has steadily got into the background and has to await the convenience of the other more urgent activities of life. Life has become more complicated in all directions. The code of conduct, which formerly was regulated by the simple ten commandments, has now to be regulated by a whole army of learned lawyers and the ever growing volumes of law books.

Commercialisation of crops.—One very important result of the contact with the West has been the development of the export and import trades which have affected profoundly the kind of crops grown and both the occupation and mode of life of the villager. It is steadily dragging him out of his isolation and throwing him into the world currents of commerce and industry. He is not content to grow crops to meet the needs of his own village but finds it more 'profitable' to grow what are termed 'commercial' crops for outside markets as distant as New York or London. This has upset the old time food centred economics of the village and rendering them increasingly money centred. The more enterprising and intelligent of the villagers are attracted by the commercial life and tend to shift themselves to the nearest town or city temporarily in the beginning but often permanently in the end. It is no wonder that such great changes have brought in their train a variety of problems connected with our villages.

VI. The Present-day Village.

Village agriculture.

Dependent on monsoons.—As agriculture is the sole occupation of the villager its present condition and its effect on the economics and life of the villager are well worth consideration. One outstanding feature connected with Indian agriculture is its great dependence on the Monsoons. In spite of the great irrigation works—some of them the largest in the world—and the steady advance in the matter of tapping underground water, it has been

estimated that seven eighths of our agriculture are yet dependent on the monsoons. Any one who has had to do with crop growing will realise how erratic the monsoons are both in time and quantity of precipitation. The unevenness and uncertainty of results in spite of his best efforts in the matter of cultivation and selection of seed, caused by factors beyond his control—such as drought, floods, and cyclones—render agricultural income unsteady and uncertain.

No touch with markets.—Secondly, the villager is so little in touch with world markets wherein the results of his labours are evaluated and sold, that a large portion of his profits is intercepted by the intermediate agencies that market his produce. This is why the increase in the export trade has had comparatively little effect on the prosperity of the village as such. It is the towns that have chiefly gained from it. For the same reason there is but little adjustment of the crop areas to the prevailing market demands. A crop is often grown because it has been customary to grow it and not always because there is a demand for it. This results in occasional over-production quickly reflected in a fall in prices; and there is a time lag before its effect is seen in the contraction of area under the crop. This is an uneconomic and backward method of adjustment.

Stress of population.—Thirdly, land available for crop growing has not increased to the same extent as increase in population. True some new lands have been brought under the plough and yields from existing lands have increased somewhat, but such increase is much less than the increase in population. The prevailing sentiments, both social and religious, that directly encourage large numbers of children were definitely needed in the olden days of plenty of land and low population. These are obvious misfits at the present time when conditions are just the reverse. Industrialisation is known to check rate of increase in population. Rice—the main food crop of India and China—is admittedly the most suitable for densely populated areas like the South East of Asia. It gives the maximum return of food with comparatively little manure and poor types of implement and cattle. The increase in population has proved beyond the capacity of even such a crop. This has introduced a spirit of competition instead of the mutual dependence and good feeling in the olden days of plenty. It has been computed that ordinarily agriculture alone cannot support more than 200 to the square mile. In parts of Bengal the stress of population is near about thrice that figure and all dependent solely on agriculture.

Fourthly, possibility of large augmentation in acre production is severely handicapped by a variety of causes such as Subdivision and Fragmentation of holdings and the prevalence of rigid social customs and religious sentiments which cause the waste of such valuable manures as night soil and cattle

dung and adversely affect the business aspect of agricultural production. Both Subdivision and Fragmentation are inter-related to each other and result from the same cause, viz., the mode of inheritance of landed properties as obtaining in both the Islamic and Hindu laws.

Subdivision of holdings.—When land was fairly abundant and agriculture practically the only means of livelihood, it would appear but obvious justice on the death of the *pater* to divide the land equally among all the surviving members. At the same time there is a limit in size below which it becomes uneconomical to subdivide agricultural land. This bottom limit would obviously differ according to nature of soil, kind of crop grown, availability of assured water supply and other factors; but one possible correlating factor would be the area that could be commanded by a pair of oxen.

This continuous subdivision has been a long-standing feature and in certain parts has reached a considerable degree of fineness. It has gone so far as to divide the waters of a well, each sharer being entitled to so many hours of lifting water from it. Dwelling houses are also sometimes divided along their lengths with obvious disadvantage to both the units in the matter of ventilation and other facilities. Such subdivision is said to obtain in other countries as well; in France the holding is sometimes reduced to a single vine or a single tuft of lucerne grass and this condition is said to prevail also in Switzerland, Japan and Germany. But the big and material difference lies in the fact that, whereas in those countries the divided holding is only part of the owner's means of livelihood, in India it is often the sole source for employing him all round the year. Small sized holdings up to a certain limit are not by themselves wholly bad; in Denmark and Switzerland some of the best types of agriculture are said to be associated with such holdings, but the other circumstances peculiar to our country render them uneconomical in our land.

At present this evil is to some extent counteracted by certain of the sharers emigrating to the nearest towns or to countries overseas. The Indian is, however, so much attached to his land, be it small and unremunerative, that he continues to own it if not forced out by other circumstances. Its possession is not always as a business proposition but as necessary for status. This leads to the evil of absentee-landlordism. In one of the villages in the Bombay Presidency, Dr. Mann found that 36 per cent. of the owners had thus gone out of the village.

Fragmentation of holdings.—But perhaps a greater evil than subdivision is what is known as fragmentation. When one wishes to invest on landed properties he does so often by purchasing bits from different individuals and hence located away from one another. When this property is divided after his life time each sharer gets generally a portion from each of

the bits of land and thus the holding of each sharer becomes fragmented. This system is practised in the interests of absolute equality in the sharing. Lands, as is well known, differ somewhat from one another and it is considered most equitable that each sharer should have a portion of each bit of land, however distant they may be from one another.

The prevailing sizes of such subdivided and fragmented plots of land depend upon the soil, kind of crop grown and nature of irrigation supply. They are smaller on the banks of rivers such as the Ganges, the Godavary and the Cauvery with their assured water supply and larger in the open rain fed plains of the Central Provinces and the Punjab. Small holdings are also characteristic of well-irrigated areas, where the lifting is through bullock power. Rice holdings again are smaller than those growing wheat as, in the former case, fields have to be divided into small plots and bunded up to retain the needed water for this semi-aquatic plant.

This state of affairs rules out large scale operations by outside capitalists who have the resources for up-to-date agricultural methods generally beyond the reach of the average cultivator. The number of landlords they have to deal with is too large and one recalcitrant can hold up a whole scheme. The value of large scale operations in raising agricultural efficiency has been amply demonstrated in other tropical countries like Hawaii, Java and Formosa. Certain of the sugar concerns in the Bombay Presidency which are launching on large scale growing of sugar-cane are faced with such difficulties. Another disadvantage is that it precludes the fencing of the property, a valuable aid in raising agricultural efficiency. It is claimed that fencing of lands was one of the chief factors in greatly improving agricultural production in England after the Elizabethan period. The constant and unavoidable disputes resulting from these long and irregular boundaries lead to bad feeling between the villagers; and, it is said, that incendiarism of fodder stacks in the Bombay Presidency is often traceable to such misunderstandings.

Village cattle.

The Aryan settlers loved their cattle and valued them highly. A grazing waste round each has been the standard feature of the Indian village; its width was fixed at 400 cubits during Chanakya's times and in the Moghul days it was as much as the human voice could be heard across. In Vedic times the wealth of an individual was computed by the number of kine and is so in parts of our country even to this day. Unlike China and Japan where the consumption of milk as food is considered a disgusting habit, this article has been highly valued in our land and extensively used as food from ancient days. This is fortunate for a country like ours which otherwise is largely

vegetarian. Milk was not banned even in the case of the semi-recluse who was denied most other articles of diet. In the Brahmanical period the daily prayer included an invocation for the health and prosperity of the cow.

The cattle represents sometimes the heaviest capital outlay of the cultivator next only to land and he loves them almost to a fault. It is common in the Punjab to lay by, each day, a handful of 'atta' (wheat flour) so as to sumptuously feed the cattle on occasions; and it is considered an act of charity to lay along the roadside big pieces of rock salt so that the cattle can lick them on their way. A day in the year is set apart as cattle festival when they are decorated and feasted on sweet rice and cakes. In certain parts of the country like the Vizag and Bellary Districts of the Madras Presidency the cattle often occupy the front portions of houses.

But this very attachment and religious regard to the cattle —particularly the cow—is now working to their disadvantage. India is unique in possessing an enormous amount of cattle without making profit from its slaughter. The old and the weak are allowed to deplete the fodder stock of the village with the result that the fitter and hence the more useful ones do not get their due share. Cattle maintenance is not looked upon as a business proposition and the sentiment towards them is similar to that of a rider to the old horse which had served him well when he was fit and strong, or of the lady aristocrat to her pet dog or cat in the West. The sentiment is too deep-seated for a rapid change.

The Motor, the Oil-Engine, and Electricity are steadily replacing cattle power (largely of the male sex) for transport and water lifting. On the other hand, the demand for milk and milk products is likely to increase in the future and it is desirable it should be so. Fewer but better type of cattle and tended with greater knowledge of their needs, are indicated in the future. Castration in as painless a manner as possible to work out the uneconomic types from the village stock is the crying need of the countryside. The world is getting accustomed to such ideas even in the human species. With increasing knowledge of factors determining the sex of the fertilized egg will science be able to increase the number of heifers as perhaps in the future we might need more cows and less bullocks.

Village labour.

For agricultural labour the Aryan colonists would appear to have employed largely the local people—the Dravidians and aborigines. Even in those early days agriculture was considered somewhat degrading as being non-intellectual. It has to be remembered that those were times when land was plenty—often perhaps virgin soils—and hence parted with its treasures

more easily and abundantly than now. The agricultural labourer was employed more or less on a feudal basis and though the work was hard there was considerable affection between master and servant. The 'padial' system in parts of South India and the 'hali' system in parts of Bombay arose from labourers originally borrowing money against free service stipulated during the pendency of the loan but afterwards not being able to repay. He thus became a perpetual servant till released by death or emigration. The Indian labour is low both in wages and efficiency, certain extremist opinion equating a week's labour of the Indian to a day's of the Westerner.

But the demands of agriculture are such that, whereas at certain periods a large force of labour is needed, there is no demand during other parts of the year. This is particularly the case where the bulk of the area in the village is under the same crop. In the absence of work and hence wages all the year round, the labour migrates to other places with the result that, at the time of peak demand (as during paddy transplantation) there is labour scarcity. Crops like the sugarcane which need labour all the year round, greater diversity of crops or subsidiary occupations are needed for stabilising the labour demand.

The Villager (and his indebtedness).

Having briefly considered certain important aspects of village life, we are now in a position to consider the present condition of the villager himself. Though till recently but little affected by the changes around him, on account of his isolation both mental and physical, he is being made increasingly aware of the changes around by the extension into the village of such symbols of modern life as the Post and Telegraph, the bicycle, and the motor bus. Frequently also the village is visited by the townsman who is only too eager to demonstrate before the awe struck villager the elegances and conveniences of urban life. Himself a vestige of the past, he looks with wonder and admiration—and sometimes with fear—at these innovations which, on account of his little or no education, he is unable to comprehend fully.

Economically he finds himself in a very disadvantageous position owing to his steadily diminishing agricultural income in contrast with increasing expenditure due to changes in living even in his own household. Innovations in dress and habits and new wants like tea and coffee are steadily forcing up family expenses. While the community life of inter-dependence has ceased to exist, the medieval social structure like the joint family system still persists rendering the villager's life unbalanced.

Indebtedness.—Dependent as he is solely on agriculture, the need for money always exists. This is true of the agriculturist all the world over and results from the fact that, whereas agricultural income comes in only at particular times like harvest, his

expenditure is of a monthly if not of a daily nature. Extra profits from an exceptionally good year are more often wasted in urbanising his surroundings than being put by as reserve against lean years. The heavy indebtedness of the Indian villager is well known and has attracted the attention of all that have cared to study the village. In one village studied by him and his colleagues Dr. Mann found that the total debts of the village amounted to about 12 per cent. of its capital value and that nearly 25 per cent. of the profits of the village went to pay interest thereon. According to Mr. Darling, debts in certain Punjab villages amounted to as much as Rs.40 per acre, a sum sometimes greater than the annual income from it on the average of good and bad years.

The villagers' debts are also often unavoidable. It has been calculated that nearly 90 per cent. of a villager's expenditure is on such essentials as food, clothing, rent, and taxes, thus leaving but little margin for unexpected reverses such as crop failures or floods or sudden cattle mortality. Expenses on marriages and funerals, which to the villager are equally unavoidable because of his traditional ideas, are other sudden items of expenditure. The margin of extra income is so narrow that the loss of a buffalo or the long illness of the working member in the family is known to drop the villager down in the social scale sometimes never to recover to his original position. The only security he can offer against such debts is the land, his only possession in this world, and once pledged he finds it difficult to redeem it.

Village wastes.—While on the subject of the economics of the villager it will be appropriate to consider here the various types of waste that are taking place in the village. Foremost, perhaps, is the agricultural waste resulting from the uneconomic subdivision and fragmentation of land which precludes its cultivation to maximum benefit. Then come the waste of cattle and human labour due to fragmentation, the drain of village money by way of interest on loans raised by the villagers and loss of valuable manures like human and cattle voids. Cattle manure is wasted as it is needed for fuel. It is such a suitable fuel in the Indian household that a substitute alone will be operative in bringing about its rapid discontinuance as fuel. Human voids instead of being utilized as in China and Japan, are allowed to render the streets and surroundings unsanitary and poison the clean country air. There is considerable waste of both energy and material resources through adherence to sentiments and habits which, perhaps useful in olden times, are useless and wasteful under the changed conditions of to-day.

One important waste which has to my mind far-reaching results is that caused through forced idleness. This is because agriculture, which is often the sole occupation, is not able to keep the villager busy all the year round. This forced idleness is very harmful, changes his whole outlook on life and lowers

his character in many ways. No tonic is so good as healthy and steady work all through the year and this is denied to the average villager. The comparative prosperity of villages located near towns or industrial centres proves the advantages of employment all through the year.

Standard of life.—One common complaint laid at the door of the Indian by others and of the villager by the townsmen is what is termed 'low standard of life'. There exists, however, considerable confusion as to what the term really means and though it is but vaguely understood, it is nevertheless readily resorted to, when there is no room for sound and logical reasoning. To put it briefly and in easy language, a higher standard of life may be defined to consist in getting more out of life's opportunities to the advantage of both the individual and his society. A rise in the standard of living must add to the productive efficiency of the individual or it is no HIGHER though it may be a DIFFERENT standard. All real progress and civilisation is interpretable only on this basis. But when a townsman, weak in physique through wrong and unsanitary living, with a diversity of unnecessary and unhealthy wants and unnecessarily and perhaps also harmfully dressed, talks of his higher standard it is an obvious misapplication of the term. It is a case of a more EXPENSIVE and not HIGHER standard of life. A healthy cultured villager with his fewer and simpler needs but greater depth of character is easily the superior.

The merchant, with his desire for commerce, has a tendency to synonymise 'higher standard' with 'increased wants and greater purchasing power'. While an increase in wants as the result of a fuller life—such as books, works of art or facilities for quicker locomotion—does represent a higher standard, it ceases to be such when the increased wants are unnecessary, wasteful or harmful to the individual or society.

VII. The Exodus from the Village.

The most serious of the unfavourable changes coming over our villages is the steadily increasing exodus of people from the village to the town. There is little doubt that the villages were comparatively more populous in the olden days. The Arthasasthra contemplates a normal population of 500 to 1,500 against the present average of about 400. One main reason for this exodus is the growing inadequacy of agricultural income not supplemented by income from other sources. A second reason is the shifting of the main activities of life to the town. Educational facilities and other urban conveniences are increasingly attracting the villagers to the town. Dr. Mann was struck by the significant absence from a Bombay village of youths between the ages of 14 and 20; and this is largely true of other provinces as well. They had gone out for education or to seek employ-

ment. When a person has lived in the town for some time he often develops a dislike for village life with its limited comforts. He misses in the village various things to which he has become accustomed in the urban surroundings; he misses the rapid means of locomotion, the quicker life of the town, the facilities for shopping, the pictures and the like. He finds a comparative dullness in the village surroundings which makes him loath to return to it.

Apart from the number, the quality of human material contained in the exodus constitutes a serious drain. Take, for instance, a family of four sons all of whom had gone to the nearest town for education. The successful ones get employed away from their villages in due course and rarely return to it except if at all in old age. The unsuccessful ones, on the other hand, with nothing else to do perforce return to the village and settle there, thus increasing the pressure on the land often disproportionately to their contribution to the village assets. Secondly, the richer landlords who, by their superior resources, could, if they cared, undertake experiments or launch fresh agricultural ventures, are attracted to the town and leave behind in the village their less resourceful brethren. Similarly, the capable artisan leaves for the town to make the most of his talents. Culture is now town-centred and there is little scope in the village for the full development or unfolding of one's talents. In the olden days when the village was practically autonomous and had its own funds to cater to the needs and amenities of the village the opportunities in the village were greater; and it was possible to retain in the village at least a portion of the intelligentsia, though even then the best of talents resorted to the capitals or courts of Kings for patronage.

VIII. Rural Life and Agriculture in China.

The one country in the world whose conditions of rural life and agriculture are similar to our own is China. That country presents many points of similarity with ours and a few contrasts.

The Chinese also have a civilisation as old as ours and in ancient days there was a certain amount of contact between the two nations. The national religion of China had its origin in our land and the Chinese sent out an industrial commission to Bihar as early as the sixth century to learn the process of sugar manufacture. The two Chinese travellers to our country, viz., Fa hien (399–414 A.D.) and Hiuentsang (629–645 A.D.) and their writings are well known. Like its Indian prototype the Chinese village also has been isolated from world changes and the bulk of the people in that country also live in villages and hamlets. They lead a comparatively simple life and their holdings are small. Density of population in China is greater than ours, their agricultural implements primitive and most

systems of land tenure existing in our country are to be found in China as well.

But the Chinese are specialists in small scale farming and are adepts in taking the maximum from their lands. They have made the conservation of human voids for manurial purposes almost a fine art, and their agricultural operations are so intensive that they often raise a multiplicity of crops on the same land. By an extravagant use of human labour which is highly intelligent and cheap, they make for want of efficient tools and scientific equipment. They possess unusual gifts for quality production. We in India are familiar with the peripatetic Chinese silk merchant with his large bundle of silk pieces strapped to his back—a symbol of hard work and perseverance. Human labour is cheap in China and, in spite of the existence of modern cotton mills, some of the spinning and a great deal of the weaving is still carried on in the villages as cottage industries. Like us they are also now faced with the sudden inrush into the villages of western achievements and organisation and the solution of our common problems would probably have to be on parallel lines.

IX. Villages in Other Lands.

Danish Village.—The villages in Denmark are good examples of what co-operation, education and the linking of agriculture with other industries carried on in the village itself can achieve in the development of small scale farming. The subsidiary industry in this case centres round the Cow and its products. During the decade 1880–1890 the Danish villages were in a bad way from the effects of the aftermath of the Napoleonic and Prussian wars ; and there was manifest a tendency for the people to leave the village for the town. In that decade the increase of population in urban areas was 325 per 10,000 against the corresponding figure of 21 for rural areas. But by the quinquennium 1901–1906 conditions had so altered through organisation and rural amelioration work that the figure rose to 99.

Holdings in Denmark are comparatively small, most of them being not much more than eleven acres. The farmers effect all their purchases and sales through properly federated co-operative organisations and thus get the benefits of large scale transactions. The Cow is an important factor in rural Denmark and aids the agriculturist with steady supplementary income. Sons of farmers get regular training as apprentices before being allowed to take charge of farms. In our country, on the other hand, farming is the one occupation which is not considered to need any training. Such apprentices are said to constitute the chief labour in certain of the Danish farms. Every farmer is educated and well posted with regard to market trends and prices. He lives in a clean house with a well built outhouse for his cattle, the whole often forming a quadrangle with a neat garden in the centre.

The State helps in the development of efficient small farms. When a candidate satisfies the local commission that he is fit, possesses knowledge to run a farm and also produces a tenth of the capital, the State finds the other nine-tenths and no repayments need be made during the first five years. The farm is to be redeemed in the course of a hundred years and during this period the unit is neither to be mortgaged nor subdivided. It is said that about 50 per cent. of such farmers have made a success, about 30 per cent. are just getting on and the rest failures. Such small farms—with the products of the cow as the subsidiary industry—are said to have proved more efficient in adding to national wealth than capitalistic farming on a large scale.

Swiss Village.—A sense of absolute justice and fairplay is said to be the outstanding characteristic of the Swiss villager and this, it is said, has made Geneva the logical seat of the League of Nations. The Swiss farmer also depends a great deal on the Cow which he duly insures. They have accident and harvest insurance companies and State insurance against unemployment. The villager commands all modern conveniences like electricity in his village house and every farmer makes his own wine as a cottage industry. The government of the village is vested in a Council who do the work in an honorary capacity.

X. The Future of the Indian Village.

After this rapid review of the Indian village in the past and the changes that have been coming over it up to the present time we are now in a position to consider its future. There is little doubt that the general tendency so far has been for the village to steadily go down in prosperity and importance in contrast to the town which has increasingly drawn the best from the village. The question to consider is, if this is in the best interests of our country and, if not, are any steps needed to place the village in a better position than now. Does the future lie in a greater and further development of urban life, evolving measures that would somewhat mitigate the inevitable disadvantages associated with it or does the situation need radical changes in the village and village life, importing into it certain characteristics of the town ?

In spite of its having become trite, the statement that ours is an agricultural country warrants repetition on account of its far-reaching effects on all our activities. The plough with a pair of oxen is perhaps the one symbol that would properly represent India as a whole with its different classes and communities. Secondly, the rapid increase of population in our country and China has become a byword and this renders incumbent a further increase of agricultural production. Science has so far not succeeded in growing crops on the roofs of houses or on road-sides in towns and the best achievements of agriculture

have been in the countryside. The clearly indicated line of advance for the future, therefore, lies in improving rural conditions and rendering our villages better and more efficient in the discharge of duties set to them by the country as a whole, viz. : (1) the proper and adequate feeding of the steadily increasing population, and (2) rearing a healthy stock of men and cattle and maintaining them in a fit condition.

Both town and village are needed for the full and complete development of our country as a whole. The town is a natural and inevitable product in this development. 'If God made the country' the town was and is being made by man, His agent, and in response to forces no less natural in the broad sense of the term. Ours has been and still largely is a land of villages but the towns have risen up and are bound to multiply and expand in the future. In recent times there has been a growing tendency to centralise culture and activities in the town to the disadvantage of the village ; and the towns and cities have in a sense grown at the expense of the village.

But each has certain specific advantages and inevitable defects. In crop growing, when one comes across two types both of which possess desirable characters, the crop servant—called the Breeder—tries to raise hybrids between them for producing kinds which might combine in themselves the good points of both and eliminating as far as possible the defects of either. This process of hybridisation is neither new nor recent. Nature has been doing this since the beginning of life and the existing crop types are the result of such so called 'natural' hybridisation and selection. A similar procedure is indicated between the town and the village and such a process is already in progress. The open air extensions that have grown round towns in recent years—with compound houses and gardens—indicate the attempt to ruralise the town in the matter of health and surroundings, while the Post Office, the rural dispensary, the school, and even the bus horning its way through the village are in the nature of urbanising the countryside. Suburban colonies also represent such an endeavour to combine the advantages of both country and town life. While the process is already in action it is desirable to speed it up by conscious endeavour.

Improving agricultural efficiency.

Elsewhere we have considered certain serious handicaps the present-day village agriculture is labouring under. Thanks to the good work inaugurated by Lord Curzon's Government about thirty years ago reinforced and supplemented by the elaborate and far-reaching recommendations of the ROYAL COMMISSION ON AGRICULTURE of 1930, we are now in a position to feel that technical advances in agriculture and allied sciences can be taken to have been provided for. The Imperial Council of

Agricultural Research, a lusty child of the Royal Commission, has already won back to us a major industry and is engaged in grappling with problems of fundamental importance like marketing.

While on this point I cannot resist the temptation to refer to the outstanding achievements in the breeding of valuable crop types. Our most rapid and effective advance in agriculture has been along this line and to-day almost every crop is being systematically bred all over the country. Advance in this direction—viz., the improvement of crop type and distribution of its seed—has been the most suitable to our present conditions of comparative poverty of resources in other directions. For the production of these types the resources in the way of plant material of more than one country has been and is being systematically employed. Combined with substantial Tariff protection afforded by a kind Government, it has resuscitated our sugar industry and thus saved a drain to the country of 15 crores of rupees per annum on the average. It is employing a hundred thousand additional labourers in the factories and about 1,500 graduates in these days of unemployment besides the five million extra agriculturists directly benefiting from it. This demonstrates the great value to the country as a whole of industries founded upon our own agricultural products.

That it is possible to augment the agricultural income of the villages to a considerable extent is evident from the fact that even in the West, which is much more advanced in this matter, the opinion is held that further marked advances are possible. A recent theoretical calculation has shown that, under the best of conditions and with the needed machinery and organisation, twelve able-bodied men are sufficient to cultivate 365 acres of sugarcane and from it supply the carbohydrate needs of as many as 14,500 men and that thirty-five individuals could be fed from the produce of one acre, if properly handled. It is true that these calculations are somewhat theoretical as they assume conditions which do not exist and which it may be difficult to fully materialise, yet they are useful indicators of possibilities in the direction.

The evils resulting from subdivision and fragmentation of holdings have already been noticed. These are beyond the capacities of technical departments to remedy, however earnest or well organised they may be. They are caused by ideas and sentiments deep-seated in peoples' minds and legislation is the only remedy. It is a matter where we have to help ourselves and submit to certain hardships in the interests of the country as a whole. Other countries have shown the way. In Austria the economic holding is recognised by the law of the country and is both indivisible and unmortgageable (except for short periods). In Italy such holdings are said to be inalienable, indivisible, and unseizable. In Denmark a law passed in 1837 provides for

the proprietor leaving his farm intact to any one of his children and providing moderate consideration for his other heirs. It is gratifying that certain Provinces have initiated action in this direction.

The human element.

Literacy and education.—As the efficiency of any programme of rural improvement depends primarily on the Chief Agent in it, the Villager, it is important to consider means for increasing his efficiency. If we compare the Villager with the Townsman one point in which the latter often scores over the villager is his literacy if not always his education. This is not the place nor is it necessary to detail the various advantages of education or even literacy. Suffice it to say that even in elementary education we have a very effective weapon for bringing the villager out of his narrow horizon, breaking down his superstitions, placing him in touch with the rest of the world through the printed word and for facilitating the introduction of various reforms for his betterment. In the progressive evolution of the human species acquisition of certain characters such as the 'erect habit' are credited with having introduced far-reaching effects. Education belongs to this category.

Though it is true that the village Teacher did exist in the olden days and at least certain classes of the population received some kind of school and even higher education and though there is evidence that reputed universities did occasionally flourish in certain rural parts, regular schooling and education were not considered essential. While, according to the Arthasasthra, the Sukranithi and the Manusmrithi, the carpenter, the blacksmith, the shoe-maker and in certain cases even the astrologer were definitely recognised in the elaborate village organisation, the school-master did not occupy such a position. It was left largely to the priest class or some men of learning to give instruction in the three 'R's' and take the more advanced students even higher up the scale in return for voluntary gifts from the parents of the boys in their charge.

Education given in the village school should obviously possess the rural and agricultural outlook and be vitally linked with the every-day life of the village. In our boyhood days we learnt more about the geography and history of places we could never hope to see while being comparatively ignorant of our own district and its environment. Such an important subject as the anatomy and physiology of the human body was reserved till the student had mastered the various distinguishing characteristics of the metals and the non-metals or the names of the then two important towns in the Sahara region. There is now a steady and welcome change in this matter. Nature study lessons fit in well with the agricultural life of the villager and I have often wondered why the village vacations should be

timed to the conveniences of metropolitan examinations rather than to the busiest agricultural seasons in the village when the boys could perhaps help their parents in the field and gain first-hand knowledge of subjects taught in the school-room.

Intellectual alertness.—A second characteristic of the Villager as contrasted with the Townsman is often the slower moving intellect of the former. This is not mentioned here in a derogatory spirit; the difference is due to difference in the environment. The every-day struggle with the great forces of nature develops a deeper character in the villager, but in intellectual alertness he is often inferior to the townsman. Agricultural operations are generally spread on the broad land and hence the workers are in comparative isolation, whereas intellectual alertness is greatly accelerated through contact and clash with other minds, a feature of industrial life. The rather extreme opinion has been held that most agricultural improvements themselves have been from men whose intellects have been sharpened by industries and commerce. The linking up of villages with towns and other villages, through better communication facilities, for instance, will remedy the situation.

Business habits.—Yet another common defect of the villager is the lack of so-called ' business ' habits and ' business ' mentality. This again is due to his environment and tradition. Nature's processes with which the Village Agriculturist is primarily concerned do not generally need the punctuality of the man of business or commerce. The cow is insured both in Denmark and Switzerland on account of its importance in rural economics. The absence of insurance measures in our villages against crop failures and cattle epidemics, which are by no means uncommon, is largely attributable to the absence of education and business outlook. The villager's income would be both enhanced and rendered steadier by the import of the ' business ' mentality into his activities such as agriculture and cattle maintenance.

Outlook on life.—The villager's outlook on the world is often narrow because of the isolation and the absence of literacy. Whether he likes it or not, the villager is being dragged into the world currents of commerce and industry and his horizon needs to be broadened by education. His constant fight with forces of Nature over which he has little control, tinges his ideas with almost fatalism. A bad season too often disproves to him the truth in the saying ' As you sow so you reap '. Industrial activities, on the other hand, are associated with processes which demonstrate the control of natural forces by man and this has a tendency to develop in him certain amount of self-confidence, if not of human pride.

Cottage industries.

In this study of the Indian village, the villager and village life, we have frequently noticed the need and advantages of

industrialising the village. We have found that industries are desirable in the village to find employment for the people all through the year, to stabilise labour, to tone up the villager in various directions and to supplement and steady his income. The large scale industries, which have developed in the country—while both useful and important for the progress of the country as a whole—have helped the villager but little. On the other hand, they have adversely affected the village tending to draw labour and brains away from the village. What is needed is the establishment of cottage industries in the village itself so as to improve the conditions for living in it.

It is obvious that the closer such industries are linked up with agriculture and agricultural products the better they would fit in with village economics. Cattle being an important adjunct of agriculture, industries like cattle breeding and production of milk and milk products at once suggest themselves. The value of cattle for agriculture is not confined merely to its use as labour, but the trend of recent work is indicative of their playing a very important part as the store house of the right type of manure for crops. The animal and plant kingdoms would appear to be the counterparts of one unit, each benefiting from the waste products of the other. Bee keeping, the poultry industry, fruit growing and canning and preparation of tinned and infant foods for the benefit of the townsman would fit in well into the village.

Other suitable industries would be the partial preparation of manufactured products in the village itself as a rural industry. Cotton ginneries, seed decorticators and oil presses belong to this group. It saves in the transport of raw material to the central factory, the half-prepared material being generally less bulky than the original raw product. The retransport to the village of the bye products of manufacture, such as seeds in the case of cotton which are needed back in the village both for sowing and as cattle food, is also thus avoided. Minor industries connected with products or articles available in the village or vicinity, such as cocoanut industry in the West Coast and fish curing in seashore villages, help to keep the villages prosperous.

Other handicrafts and domestic industries, where the needed material is imported from outside and worked in the village during the off-seasons, include weaving, dyeing and the manufacture of toys and trinkets. In spite of technical advances there are yet certain industries which lend themselves to be worked in the villages as domestic industries. The manufacture of toys in the Black Forest regions of Germany, watches in Switzerland, cutlery in Sheffield and little fans, flower baskets and ornamental pieces in Japan are of this class and are a great help in supplementing and steadying the villager's income. The mechanical efficiency obtained in the village as the result of such rural industries gives the village a 'mistry' class who should prove

increasingly useful in the repairs and upkeep of farm machinery and water lifting pumps which are spreading in the country.

Co-operative organisation.

The value of organising on a large scale for increasing efficiency is well known and widely accepted. Most village activities, on the other hand, have by their very nature to be on the small scale and their being grouped together through co-operative organisations is the only remedy. Through them even the small farmer and producer is enabled to command facilities and advantages generally available only to large scale units. The purchase and sale of articles connected with cottage industries, for instance, need grouping together through co-operative organisations for best results.

There was apparently a great deal of the 'mutual help' and co-operative spirit in the villages of old. Certain of these are surviving to this day in the form of customs or usages, sometimes transmuted into religious observances and thus commanding unquestioned obedience. In the remote countryside marriage or death in a family is often a village event and is shared by the whole community even in these days. Guests at marriage functions come in with a variety of contributions including provisions for the marriage feast. The inhabitants of a street are forbidden to take food till the dead is removed and properly disposed of and food for the bereaved family is provided by other villagers for the first two days. The spirit needs to be revived and placed on new lines consonant with the modern age.

Amenities of life.

As a class our villages lack the conveniences and amenities of urban life. While perhaps certain of these might be considered unnecessary and a few even harmful, there can be no doubt that the bulk of them are in tune with and are necessary for modern progress which is taking hold of the world whether we like it or not. Conveniences like means for rapid transport, the Post and Telegraph, the Newspaper and the ever-increasing improvements associated with the development of electricity are major blessings which it is desirable should be extended to the villages as quickly and as completely as possible. It is the absence of these in our countryside that is partly responsible for the prevailing distaste to village life. The village is easily healthier than the town in such important factors as pure air and open spaces and if only certain urban facilities are implanted in the village, its attractions for settlement should prove irresistible.

The general tendency for retired Government officials not to return to the village but settle in a nearby town has struck

me as unfortunate and is indicative of the general trend. While in certain cases perhaps the decision might be due to urban educational facilities, there is little doubt that the general unattractiveness of village life also enters into the decision. For permanent results the urge for rural improvement should be implanted in the village itself. This could be achieved only by improving the chief natural Agent in such work—viz., the Villager —and making it attractive for him to live and have his being in the village itself. Endeavours that are town centred and take to the village for temporary periods, for lectures, demonstrations or shows—however honest or energetic—have an outside flavour to the villager and do not, therefore, get permanently assimilated into village life.

XI. Conclusion.

To sum up, there is little doubt that the villages of old were more populated than they are to-day largely because of conditions prevalent at the time. Those conditions will never return however much or sincerely we may hanker after them. The town and the characteristics associated with urban life are definite products in the march of events and need to be accepted as such. Though there are drawbacks associated with urban life the town has its own good points which need extension into the village to keep rural life in tune with the changes around us. *At the same time, the countryside has advantages like open spaces and absence of congestion which can never be reproduced in the town.*

Life activities that were village centred in the past are increasingly getting town centred to the disadvantage of the former. In the interests of the country as a whole relationship of mutual help needs to be established between the two. The town should extend to the village its greater knowledge, quicker living and the manifold amenities of the modern age. Contributions from the countryside are of equal importance. It alone can produce the raw materials of commerce and industry and thus help in the growth of towns and cities. It alone can supply adequate and wholesome food to the millions of our land whether resident in the village or town. Lastly, the countryside alone can imbue the urban 'business' civilisation with the deeper character and larger humanities which are nurtured in the villager through his more direct and constant contact with the great forces of Nature and of life. Our duty then is clear: namely, to improve the *Village*, the nucleus of our country life, and infect its Chief Agent, the *Villager*, with a chosen culture of the virus of modern age through *Education* and *Industrialisation.*

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SECTION OF MATHEMATICS AND PHYSICS

President :—S. DATTA, D.Sc., F.N.I.

Presidential Address

ABSORPTION OF LIGHT BY ATOMS AND MOLECULES

GENTLEMEN,

I deeply appreciate the honour you have done me in asking me to preside over the deliberations of your section.

In these days of duality of the nature of radiation and when the origin of radiation is still shrouded in mystery, the subject of interaction of radiation with matter is one of vital importance to the Physicists ; and as the studies of absorption of light by atoms and molecules and problems related to it are the chief resources in obtaining information concerning such interaction, I have chosen this as the subject of my address this morning.

The discovery of the phenomenon of absorption of light, by methods of Spectroscopy, was made by Fraunhofer about the year 1814. It is rather remarkable that it escaped the notice of such outstanding geniuses as Newton and Huygens. By using diffraction grating to study the spectrum of sunlight, Fraunhofer found the continuous band of colour to be crossed by a large number of very fine dark lines, now known in his honour as Fraunhofer lines. The actual physical significance of the black lines of the solar spectrum was, however, unknown to Fraunhofer and it was reserved for Kirchoff to give their explanation forty-five years later.

The year 1859 is justly celebrated in scientific history as the memorable year in which Darwin gave the world his ideas of biological evolution. Curiously enough the same year marked the discovery of a phenomenon—itself modest in appearance, but far reaching in its consequences—and which enabled Kirchoff to form a theory of the constitution of the sun and thereby lay down the foundation of our knowledge of another evolution—the evolution of the physical universe. The results of his classical experiments on the reversal of the sodium D lines led him to suggest that the Fraunhofer lines arose by the passage of white light emitted from the glowing hot photosphere of the sun through the incandescent vapours of many substances lying in the reversing layer of the chromosphere, which act as filters, so to speak, of the pure white light.

Section I—Absorption by Atoms—Line Absorption Spectra.

In accordance with the classical theory of radiation, as expressed by the usual interpretation of Kirchoff's law, all emission lines of an element are expected to appear as absorption lines, when the light from a source emitting continuous spectrum is made to traverse a column of the vapour or gas before it is submitted to spectral examination. Actually, however, the absorption spectrum of an element is much simpler in character than its emission spectrum and out of the various series in which the emission spectrum of an element can be classified, those belonging to one series only come out in absorption.

Kirchoff's theory thus needs some restriction and the absorption of only one series of lines in preference to all others is explained by the simple Bohr theory, according to which the atom is capable of absorbing monochromatic radiations in quanta of frequencies or energy values just sufficient to displace the valence electron from the level of the normal atom to higher energy levels. Radiation of frequency corresponding to energy intermediate to two outer orbits leaves the atom unaffected. Now, the relative proportion of atoms in the various excited states is given by the expression :—

$$n = n_0 \cdot (g/g_0) \cdot e^{-\Delta W/KT},$$

g and g_0 being the weight factors (equal to $2j+1$) of the corresponding excited and normal states and ΔW the energy difference between the two states. Consequently in cold vapour, since ΔW is considerably large and T the temperature, as available in the laboratory, is not sufficiently high, n, the number of atoms in the corresponding excited state, is insignificantly small. For instance, in the case of sodium at 500°C. the fraction of atoms in the first excited state is only 10^{12} of the number in the normal state and the fraction reaches the value 10^{7} only at 1000°C. Hence at moderate temperatures all inter-orbital transfers by absorption of radiation takes place between the normal state and the state which is permissible according to the famous selection rule, originally obtained in the old quantum theory by Rubinowicz[1] from the principle of conservation of the angular momentum between atom and radiation and is now written as $\Delta L = \pm 1$. This explains the appearance of only one series of lines as absorption lines.

This selection rule, however, is not rigorously followed, for it was first shown[2] by the present speaker that with cold potassium vapour the lines $1s-3d$ and $1s-4d$ are also obtained in absorption under conditions in which the incipient Stark effect, usually held responsible for the breakdown of this rule in emission spectra, cannot presumably be operative.

The view-point, however, has slightly changed. The above selection rule which was deduced on the assumption that the atom can radiate only when it has a dipole moment is now somewhat modified by the supplementary condition that it can also radiate feebly when it has a quadrupole moment. Including the first quadrupole radiation the selection rule takes the form $\Delta L = 0, \pm 1, \pm 2$. This new rule has also been proved by Rubinowicz[3] to hold in wave-mechanics.

By employing a somewhat higher pressure or using a longer column of the absorbing vapour, the 'ground series' may be obtained in absorption close up to the limit. This makes it possible to accurately find out the energy value of the normal state and determine its term type in a convincing manner. In this way the study of the absorption spectrum has been fruitful for the identification of the normal term, which would have otherwise remained controversial and undecided from a study of the emission spectrum alone. Reference may be made to the controversy about the normal level of the iron atom.

The superabundance of atoms in the normal state is the only reason for the appearance of the ground series of lines in absorption to the exclusion of all others. This is clearly brought out by experiments with vapours of group III of the periodic table. Each of these metals, unlike those of groups I and II, has a P term as the normal state, which is a doublet of wave-number difference that gradually increases with atomic weight. Consequently at comparatively low temperatures, for heavy elements, all the vapour atoms exist in the normal component ${}^2P_{\frac{1}{2}}$ state. In the case of aluminium, however, the difference in the internal energy of the atoms between the two terms being small, considerable number of atoms exist also in the ${}^2P_{\frac{3}{2}}$ state. The result is that, whereas with aluminium, the absorption lines originating from ${}^2P_{\frac{1}{2}}$ and ${}^2P_{\frac{3}{2}}$ levels make their appearance simultaneously, there is a marked difference in temperature necessary for the appearance of corresponding lines in the cases of gallium, indium and thallium. The temperature difference as recorded by Grotrian[4] is least in the case of gallium (about 50°C.) and greatest for thallium (about 400°C.). This is in agreement with the theory and consistent with different values of the excess energy content of the atoms in the metastable state, and provides a proof for the validity of Maxwell's law of distribution.

A further example is provided by absorption of thermally excited atoms. Sur and Ghosh[5] were the first to show that, whereas at moderate temperatures the vapour of potassium absorbs only the ${}^2S_{\frac{1}{2}} - {}^2P_{\frac{1}{2}, \frac{3}{2}}$ lines (commonly called the principal series of lines), at much higher temperatures (1200–1300°C.) a number of doublets of the diffuse and sharp series (P-D and P-S combinations) also make their appearance. Similar evidence

of absorption of atoms thermally excited to $^2P_{\frac{1}{2},\frac{3}{2}}$ states has been obtained by King[6] in furnace spectrum with vapours of alkalies. The temperature in the sun being much higher than that available in the laboratory, excited levels are populated enough to show absorption of lines originating from these levels. This explains the appearance in the Fraunhofer spectrum of so many series of lines.

The stimulus given by an electric discharge through a gas or vapour under reduced pressure acts identically in the same way as thermal stimulus in maintaining a stationary concentration of excited atoms. Absorption by electrically excited gas therefore gives lines of the higher series originating from such states. Ladenburg and Loria[7] in this way first secured the absorption of H_α and H_β lines. Absorption by many other atoms electrically excited is on record, notable amongst them being those of helium by Paschen[8] and by McCurdy,[9] of neon and argon by Meissner[10] and of mercury by Metcalfe and Venkatasachar.[11] The electrical stimulus merely serves to increase the population of excited atoms and has no other action in stimulating absorption of higher series of lines. For, instead of passing an electric discharge, in which excited atoms are formed by the recombination of ions and electrons, if atoms are excited by collisions with electrons of controlled velocity, identical results are obtained, as shown by de Grott[12] with neon atoms.

The fact that any form of stimulus, which increases the concentration of excited atoms, would give rise to absorption of higher series of lines, is more clearly brought out by absorption due to optically excited atoms. When the normal atom is raised to a higher energy level, its usual fate is to revert to the normal state after a brief period in the excited state, of the order of 10^{-8} sec. for excited levels and $10^{-2} \simeq 10^{-5}$ sec. for metastable levels. Consequently the chance of its excitation to a still higher level by absorption of suitable quanta of radiation is exceedingly small. But by increasing the probability of the first step excitation by subjecting the atoms to intense radiation, it is possible to increase the concentration of atoms in the excited state to such an extent that a step-up excitation to a still higher level by absorption of light is rendered probable. The classical experiments of Fuchtbauer[13] with mercury vapour is a clear example of such step-by-step excitation of atoms by purely optical means.

The phenomenon of absorption is not only confined to the excitation of the valence, i.e. the outermost electron of an atom. With suitable frequencies of the incident radiation, excitation of the inner electrons to allowed levels is also possible. Thus Beutler[14] has obtained in the cases of Zn, Cd, and Hg absorption lines corresponding to transitions $5d^{10}6s^2(^1S_0)-5d^9 6s^2 np(^1P_1)$

arising from the transfer of the electron from the inner $5d$ level to the external np levels.

It is now possible to generalize and say that :—

(1) The line absorption phenomenon is entirely dependent on the concentration of atoms in energy states which are possible under the experimental circumstances.

(2) It manifests a *complete and not a part absorption* of the energy of the photon with which the atom collides, provided that this energy is exactly equal to the amount required for the transition of the atom to higher states which are permissible under the selection rules.

The phenomenon thus reveals the truth of two fundamental concepts, one relating to the photon about its indivisibility, which is sometimes questioned and disregarded, and the other relating to the discrete energy states of the atom, which continues to hold true though in a slightly modified form. For, according to quantum mechanics, the energy states of an atom, which follow from quantum theory, are not to be thought of as a sort of discrete levels, but as a kind of short continuous spectra in which the probability distribution of the electron is concentrated in regions where the terms are observed. Thus discreteness in the sense of uniqueness of the value is true only in a modified form. Every line, even in the absence of all external disturbing agents, has a finite breadth and hence the term values are not unique but are grouped within a small range about a mean value. This is quite understandable from Heisenberg's uncertainty principle.

Transformation of absorbed radiation.

What happens to the radiation when it is absorbed ? The absorbed photon loses its identity as an indivisible packet of energy and forms a part of the total energy of the excited atom, which is liable to dissipation according to the circumstances of its situation. Thus :—

(*a*) The excited atom may revert to its original state re-emitting light of the same frequency, producing the well-known phenomenon of resonance, first observed by Wood.[15]

(*b*) The excited atom may return to a different lower state giving rise to the familiar phenomenon of fluorescence, initially observed by Stokes.

(*c*) By a 'collision of the second kind' a normal atom or molecule may take up the energy of the excited atom, either as translational energy or as energy of excitation or, in the case of molecule, as energy of dissociation. The excited atom then reverts to its original state by a radiationless transfer, while

the colliding atom or the molecule either emits the fluorescent radiation corresponding to its excitation or gets dissociated. The effect was first observed by Cario and Franck[16] in thallium vapour, when they obtained the sensitized fluorescence of thallium lines by collision with excited mercury atoms. In such a process the excess of energy, if any, of the absorbed radiation over that of the fluorescent radiation, is distributed as the kinetic energy of the colliding bodies. Rasetti's[17] experiments on sensitized fluorescence of sodium D lines, causing a Doppler broadening of the lines due to excess energy, have given beautiful quantitative support to this idea.

An interesting point about the transfer of energy by such a process is that it is most efficient when least amount of energy is converted into kinetic energy. This was expected on theoretical consideration by Nordheim[18] and by Carelli.[19] Later on Kallman and London[20] have shown by the application of wave-mechanical principles that if two atoms have energy levels lying near together, a 'quantum mechanical resonance effect' takes place between them, increasing the probability of such transfers. Beutler and Josephy[21] have succeeded in confirming this idea by observing the intensities of various sodium lines appearing in fluorescence sensitized by excitation with mercury line of wavelength λ 2537.

Another prediction of the quantum mechanics by Wigner[22] is that in collisions of the second kind, the spin angular momentum would be conserved. This also has been confirmed by Beutler and Eisenschimmel[23] by investigation of the change in the intensity of mercury radiations $8^1D_2 - 6^1S_0$ and $8^3D_n - 6^1S_0$ caused by the addition of krypton, which has an energy state $^3P_2$ close to 8^3D_n and 8^1D_2 of mercury. The krypton atom excited from the normal $^1S_0$ state to the $^3P_2$ state may transfer its energy to the mercury atom raising it to either 8^1D_2 or 8^3D_n state. But in accordance with the above conservation principle the transfer actually takes place to the 8^3D_n state, thereby increasing the mercury radiation $8^3D_n - 6^1S_0$ abnormally.

(*d*) When the interaction of excited atoms takes place with molecules, depending on the amount of energy transferred, the molecules may either be excited, giving rise to their characteristic band spectra, or may be dissociated, leading under suitable circumstances to various photo-sensitized chemical reactions. The dissociation of hydrogen molecules into atoms by collision with excited mercury atoms, as is proved by the capacity of these atoms to reduce oxides, is a well-known example of the process.

Intensity of the absorption lines.

It is a recognized experimental fact that to bring about the absorption of the higher members of the ground series, it is necessary to employ a somewhat higher pressure or use a longer

column of the absorbing vapour. The reason is that the intensity of the successive lines of a series diminish very fast and hence to bring out the higher members, it is necessary to increase the 'population' of the absorbing centres. This suggested that there must be an inherent transition probability between each pair of energy levels. Einstein[24] introduced his well-known probability coefficients: $B_{1\to 2}$ (the coefficient characteristic of absorption), $B_{2\to 1}$ and $A_{2\to 1}$ (the coefficients characteristic of induced and spontaneous emission respectively) and from considerations of thermodynamic equilibrium between the radiation field and the atoms, deduced certain interesting relations between these coefficients. Several attempts have since been made to obtain a relation between the experimentally derived optical coefficient of absorption and that of Einstein coefficient $B_{1\to 2}$. According to Tolman,[25] the equation has the form :—

$$B_{1\to 2} = \frac{C}{h\nu \,.\, N} \int K_{\nu} \,.\, d\nu$$

where, K_{ν} is the optical coefficient of absorption, ν the wave-number of the centre of the absorption line and N the number of atoms in the normal state. From the absorption experiments it is thus possible to deduce the values of $B_{1\to 2}$ and in actual cases observed, the values for succeeding members of an absorption series form a fast decreasing progression. Although the quantum theory thus explains a decrease in the intensities of the successive lines as due to a difference in the transition probability, it does not throw any light on the more fundamental question why this probability of transition is so very different for different states.

This is better achieved in Dirac's theory of radiation, according to which, the electromagnetic field and the emitting or absorbing matter are treated as a single dynamical system. Because of the rather weak coupling between the two parts, field and matter, precise statements concerning the amount of energy in the field and that in the matter are possible. Radiation of a wave of frequency ν is treated as a harmonic oscillator of frequency ν, so that its energy contents are $h\nu(n+\frac{1}{2})$, where n is an integer. The emission process consists of a change in the system whereby energy leaves matter and raises the quantum number of one of the field's degrees of freedom by one. The absorption process is a change in which one of the field's degrees of freedom has its quantum number diminished by one, the energy going into the matter. The probability of these internal changes in unit time is shown to be proportional to the square of the matrix component of the interaction energy between the field and the matter. When this probability is calculated, it

is found that the connection between classical and quantum-mechanical quantities is obtained when the time average of the moment of the oscillator is replaced by the matrix moment of the same quantity for the transition from state a to b. Thus to calculate the transition probability, all that is required is to calculate the matrix moment

$$M_{ba} = \int u_b^* \overline{m}\, u_a\, d\tau,$$

where u_b and u_a are eigenfunctions of the atom in the states b and a, m is the moment of the electron and the integration is performed over the configuration space of the electron. Calculations of the transition probabilities for the principal series of sodium by London[26] in this way, have been fully confirmed by the experiments of Filippov.[27]

THE WIDTH OF ABSORPTION LINES.

The spectral line absorbed or emitted by even a single atom is not infinitely sharp. There are in general two processes that contribute to the broadening of an absorption line even when the pressure is low. These are: (1) Natural broadening, (2) Doppler effect broadening.

Natural broadening is due to the fact that none of the two energy levels E_a and E_b, between which a transition takes place, is indefinitely sharp but each has a finite width ΔE_a and ΔE_b respectively, due to the finite lifetime of the excited state. Each ΔE can be calculated from the principle of indeterminacy, so that $\Delta E\,.\,\Delta t \sim h/2\pi$ where Δt is the lifetime of the atom in the particular energy state. Following this idea Weisskopf and Wigner[28] and also Hoyt[29] have worked out the intensity distribution within the line as :—

$$I_\nu = (\gamma/2\pi)/\left[(\nu_{ba}-\nu)^2+(\gamma/2)^2\right], \text{ where}$$

$$\gamma = (4\pi e^2/mc^2)\left(\sum_k \nu^2_{ak} f_{ak} + \sum_l \nu^2_{bl} f_{bl}\right),$$

ν_{ak} being the frequency and f_{ak} the 'oscillator strength' corresponding to a passage from E_a to E_k , where E_k is a lower energy state capable of combination with E_a, and ν_{bl} and f_{bl} are the corresponding quantities for the jump E_b to E_l. If the line in question is a resonance line the lower state E_a is capable of no downward transitions, hence every $f_{ak}=0$, and the second term sum reduces to only one term, $\nu^2_{ba} f_{ba}$.

Doppler effect broadening is due to the thermal motion of the atoms of a gas. Atoms moving with speed v_x in the direction of propagation of light will, by Doppler's principle, absorb a frequency

$$\nu = \nu_0\,(1-v_x/c).$$

Calculating the fractional number of atoms within a range dv_x, the Doppler half-width takes the form :—

$$\Delta\lambda_{1/2} = 2\,(\log 2)^{1/2}\,(2RT/Mc^2)^{1/2}\lambda_0\,.$$

Thus, while the natural line-width is approximately independent of the wavelength, the Doppler broadening diminishes for smaller wavelengths. In the X-ray region, the Doppler effect may be neglected against the natural line-width, whereas in the optical region the natural line-width is ordinarily masked by the Doppler effect.

When the pressure of the absorbing column is increased there are two other types of broadening :—

(1) Lorentz broadening due to collisions with foreign gases.

(2) Holtsmark broadening due to collisions with other absorbing atoms of the same kind.

Experiments on pressure broadening reveal the following characteristics :—

(1) The absorption line is broadened, the breadth being proportional to the density of the atoms.

(2) The maximum of the absorption line is shifted.

(3) The absorption line becomes asymmetrical.

The explanation on classical lines due to Lorentz,[30] on the assumption that the effect of n collisions per second is to produce n interruptions per sec. in an undamped wavetrain, though successful in explaining ordinary broadening and its linear dependence on the density, is inadequate to explain the shift and asymmetry.

The first attempt at a quantum theory of pressure broadening was made by Jablonski.[31] He considered collision as a temporary formation of a quasi-molecule purely by the forces of the Van-der-Waal type, so that the upper and lower energy states of the system can be represented by the Franck-Condon curve shown below :—

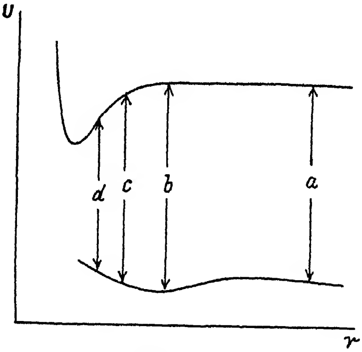


FIG. 1

If all optical transitions took place at an infinite separation the line-width would be sharp and have the normal energy E, signified by the length a of the arrow. At other separations the line corresponds to energies slightly less or greater than E, as indicated by the lengths b, c and d. The average length of the arrow is smaller than a so that the mean frequency of the spectral line is smaller than the normal frequency ν_0, causing a shift of the line to the red. This idea has been experimentally verified for Zn, Cd, and Hg by Winans in the cases of their resonance lines.

Jablonski's ideas were only qualitative and were not capable of yielding an expression for the half-breadth. This was first achieved by Margenau [32] in America and Kulp [33] in Germany. They extended Jablonski's ideas by applying a statistical theory of density fluctuations and were able to calculate the shift in terms of the pressure of the foreign gas and of atomic constants. The shift was shown to be proportional to the pressure in agreement with experiments.

The first really successful theory, according to wave-mechanics is due to Weisskopf,[34] who utilized the suggestion of Oldenburg in treating broadening as due to the conversion of the nuclear motion into light energy. Wave-mechanically it is analogous to the electron-vibration bands of a di-atomic molecule in which the energy of motion of the nuclei can be either added to or subtracted from the electron terms. In the case of the diatomic molecule the spectrum is discrete because of the regular character of the nuclear motions. In the case of the quasi-molecules, owing to irregularity of motions involved, the spectrum has a short continuity, which means broadening.

Continuous absorption by atoms.

The experiments at somewhat higher pressure reveal another interesting feature. Owing to the rapid convergence of the lines near the limit of the series, combined with the broadening of the lines at high pressures, before the very limit is reached, the spectrum appears to be continuous. The absorption, however, does not stop short at the limit, rather there begins at the limit a region of true continuous absorption, which proceeds some distance further into the ultra-violet.

While the absorption lines up to the limit of the convergence frequency mark the transitions of the atoms from the normal to the outermost orbit, the absorption of any frequency in the region of true continuous absorption corresponds to complete detachment of the valence electron from the atom. As the electron thus detached may have any velocity from 0 to ∞, absorption of all frequencies are rendered possible.

Definite proof of the occurrence of photo-ionization at this stage is furnished by the earlier experiments of Williamson,[35]

Mohler [36] and Lawrence [37] as well as by the recent works of Freudenberg.[38]

One thing is however worth mentioning in this connection, viz. that contrary to expectations, two ionization maxima have been found.[39, 40, 41] A rather weak one occurs at the series limit and a much stronger one at a considerably shorter wavelength. The densitometer curve giving records of continuous absorption also show two such maxima. As the electron, liberated by the photo-ionization of the atom, participates in the Boltzmann distribution, there is one value of the velocity, which is most probable. The continuous absorption may therefore present a maximum for that frequency which will endow the liberated electron with this most probable velocity. The appearance of the second maximum does not appear to have been accounted for.

Conservation laws and indivisibility of photon.

Up to recent times no doubt appears to have been entertained regarding the validity of the principle of conservation of energy and momentum in processes of encounter between atoms and quanta as exemplified by Compton scattering. This phenomenon is explained by applying the conservation laws to the encounter between a photon and an electron so loosely bound to an atom as to be considered free. The momentum exchange is thought of, as shown in the accompanying diagram :—

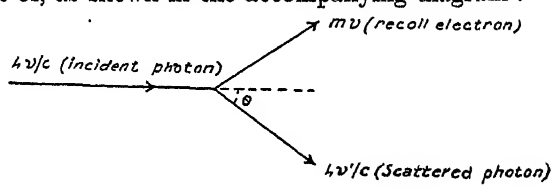


Fig. 2

as if the electron takes up a part of the energy of the photon.

Such a treatment, besides giving the correct value of the change in the wavelength of the radiation scattered in a definite direction, leads to a correspondence between the direction of the scattered quantum and that of the recoil electron. Some years ago Bothe and Geiger [42] established the coincidence experimentally and provided the proof of the validity of Compton's theory for hard X-rays. But is the principle universally true ? A few months ago Shankland [43] performed an experiment on the scattering of γ rays and found that there was no correspondence between the direction of the scattered quantum and that of the recoil electron. The validity of the laws of conservation was thus challenged. On the supposed breakdown of this basic principle, Dirac [44] thought that a new system of quantum electro-dynamics could be developed for dealing with nuclear phenomena.

The revolutionary nature of Shankland's experimental results and the support given to it by one of the most distinguished theoretical Physicists, created no little stir in the physical world. Anxieties have, however, been removed by results obtained from a repetition of the experiments by Bothe and Maier-Leibnitz [45] and by Jakobsen.[46] They have all contradicted Shankland's findings and Physicists all over the world have welcomed the results with great relief and satisfaction, as they favour the view that Compton scattering holds for high-energy photons as well.

Application of the laws of conservation in processes of exchange of energy between photon and matter entails a division of the energy of the photon. The phenomenon of discrete absorption by matter demands that the photons should be indivisible. It seems difficult to reconcile the two views. The difficulty lies in the fact that whereas matter can dissipate its energy in un-quantised fashion, photon can do so only in multiples of quantum of energy.

In Compton effect as well as in Doppler effect, where the laws of conservation are applied for the explanation of the phenomena, the photon divides into two parts, where one part is exceedingly small as compared to the other part. Is it then that such small divisions are permissible but not large ones ? If so, one might expect a noticeable change of frequency of a monochromatic beam of light by multiple reflection from metallic surfaces, as at each reflection there will be a slight modification of the frequency, which may be marked after a number of reflections. No such modifications are, however, on record.

It is, however, possible to imagine a mechanism by which the Compton effect and other results related to it can be explained, without dividing the photon. By collision with the photon, the electron may absorb the entire energy and get detached, i.e. free, acquiring thereby a forward momentum equal to that of the photon. When the energy is stored in the electron, the limitations arising from the photon energy being quantized are no longer operative. The electron can re-emit a part of its energy suffering a recoil in the process of emission in a direction reverse to that of emission. The observed direction of recoil, would, however, be along the resultant as shown in the momentum diagram given below :—

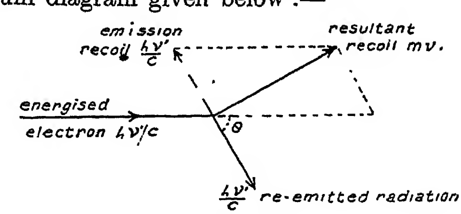


FIG. 3

Ultimately thus, the same equations are obtained as in the ordinary treatment, which give the same shift and same coincidence between the re-emitted photon and the recoil electron as in Compton's theory. There is, however, one difference, viz.: that the phenomenon has to be regarded as a kind of fluorescence and not scattering. Those objections,[47] which are ordinarily raised against the view that the modified ray represents a type of fluorescent radiation cannot be urged in the present case. The fact that according to this view the electron must be liberated in the first instance also explains why in the case of heavy atoms, where the binding energy is large, there is very little Compton scattering. Further if this view be correct, radiation capable of producing photo-ionization in gases would also show modified scattering but the momentum of such quanta being very small, the observed modification would also be very small.

Dirac's theory of electron, of course, explains the Compton effect more satisfactorily as it gives the intensity relations of Klein Nishina, which cannot be derived on the corpuscular theory.

The Doppler effect, which too is explained by applying the laws of conservation, cannot, however, be accounted on similar lines without dividing the quant. An explanation is possible if the phenomenon is regarded as merely a subjective one; and after all, the laboratory experiments first conducted by Belopolsky [48] in 1901 and later on confirmed among others by Fabry and Buisson [49] in 1920—experiments in which the Doppler effect was observed by reflection from moving mirrors—undoubtedly point out the subjective nature of the phenomenon.

Objections regarding the division of quanta also apply to Raman effect. It is well known that on the corpuscular view this is explained by the conservation of energy as :—

$$h\nu + E_a = h\nu' + E_b$$

$$\text{i.e.} \qquad \nu - \nu' = (E_b - E_a)/h = \nu_{ba}.$$

It appears that Raman effect presents serious difficulty in forming a unified theory. Even Dirac's theory of radiation, which is perhaps the only successful attempt in presenting a consistent picture of various radiation phenomena, requires doubtful suppositions in explaining Raman effect. It has to think of transitions to hypothetical levels having no real existence. From the experimental standpoint this is unsatisfactory but it obviates the difficulty of dividing the quant.

Section 2—Absorption by molecules.

As in the case of atoms, interaction of radiation with molecules brings about in them a change of energy levels, which are

in accord with Bohr's frequency condition: $h\nu = E' - E''$. But the absorption band spectra of even diatomic molecules (not to speak of polyatomic molecules) do not present the same simple appearance which is observed in atomic absorption. The complexity of the structure is essentially due to the complicated motions of the molecules, which are capable of executing three types of internal motions: (i) they may rotate as a whole about the centre of gravity of the two nuclei, (ii) the constituent nuclei may perform anharmonic vibrations relative to one another, and (iii) the electrons may be raised to higher levels.

Since a quantum of radiation in the far infra-red has small energy, the absorption of such a radiation can, as a rule, only bring about a change in the rotational energy of the molecule giving rise to what are called the pure rotation bands. Molecules with equal nuclei—homonuclear molecules—such as H_2, N_2, O_2, etc. have a symmetrical charge distribution and have therefore no dipole moment. As the reaction with radiation is only possible when the molecule has an electric moment, pure rotational absorption bands are not possible with such molecules. These are possible only when the dipole moment differs from zero as in the case of polar atomic molecules, such as NO, CO, HCl, HI, etc. or in ionic molecules, such as NaI, CsI, NaBr, etc. They are, however, on record only with the halogen halides. According to the correspondence principle such polar molecules can absorb only one rotational quantum, consequently the pure rotation spectrum forms a simple series of equidistant lines. This also explains why as a result of absorption of the infra-red radiation, the molecule does not dissociate.

In considering the vibrational energy changes for a given electronic configuration, it is profitable to discuss the phenomena with the aid of the picture presented by Franck[50] regarding the potential energy which the molecule in a given state possesses by virtue of the force which its atoms exert on one another. It is assumed that when the nuclei are at a distance r apart, the mutual force is the algebraic sum of an attractive force and a repulsive force, both of which diminish rapidly with increasing r, but according to different laws. The laws are also different according as the binding is atomic or ionic. These forces exactly balance one another at a particular distance r_0, which determines the equilibrium positions of the nuclei. For distances less than r_0, the repulsive force is larger, and for distances greater than r_0, the attractive force is larger. The potential energy curve would then be determined by three conditions: (i) it has a minimum $U = E_e$ at $r = r_0$, where the whole energy is electronic, (ii) it increases rapidly and would become infinite at $r = 0$, i.e. if the nuclei could be united, (iii) it approaches asymptotically a finite value U_∞ as r is indefinitely increased, and the molecule is dissociated; the difference $U_\infty - E_e$ would then measure the corresponding energy of dissociation.

The general form of the $U : r$ curve is indicated in fig. 4 :—

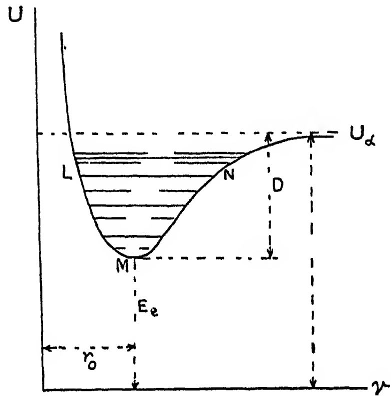


FIG 4

The occurrence of a minimum of energy at r_0 is a necessary condition for the formation of a stable molecule. When any stimulus is supplied, the potential energy increases, say to *LN*, and the nuclei are set to vibration along the internuclear axis, the amplitude of the vibration being determined by the distance *LN* intercepted by the $U : r$ curve. The kinetic energy of the vibration is given by the vertical distance between the level *LN* and the arc *LMN*. In this way, a number of vibration levels can be conceived to be contained within the hollow of the $U : r$ curve.

Light of suitable frequency can only react with molecules for which the oscillations of the nuclei are accompanied by oscillations of the dipole moment. Hence in polar molecules only, a transfer from one vibration level to another is possible, giving rise to the well-known vibration-rotation absorption bands. A non-polar molecule, as it has no electric moment, is indifferent to the action of light. According to quantum theory, a system of this kind can absorb any number of vibration quantum. Practically, however, only a few quanta are absorbed, and it is not possible to dissociate a molecule by increasing its vibration energy alone. This cannot be understood by the quantum theory but admits of explanation according to wave-mechanics as it gives the probability of transition to the limiting vibrational states to be vanishingly small. Vibration rotation bands of diatomic molecules so far obtained are for halogen halides, CO and NO.

When the energy of the incoming radiation is large, an electron of one of the constituent atom itself responds to the radiation. Consequently the restriction hitherto imposed on the non-polar molecules for not having an electric moment no

longer acts. Both the polar as well as the non-polar molecules can respond to such radiations of suitable frequencies and absorb them.

As in an atom the ground state is only one among many states, distinguished by the configuration of the electrons, so in a molecule, there are other electronic states in addition to its ground state, each of which is characterized by an energy curve $U : r$ To every $U : r$ curve with a minimum there belongs, just as in the ground state, a sequence of vibration and rotation levels. Transitions to these from those associated with the ground state give rise to the characteristic electronic band and its fine structure. In the cases so far recorded, electronic bands in absorption are obtained only with atomic molecules polar or non-polar, as in their cases alone the upper curve may have a minimum signifying a stable formation. In the cases of ionic molecules, absorption of light usually causes a transfer of the electron from the anion to the cation ; in molecules consisting of singly ionized atoms, such as NaCl, CsI, etc., such a transfer would lead to the formation of unstable molecules producing a continuous absorption. In molecules consisting of doubly or more ionized atoms, even after such transfers stable configurations are possible. The corresponding banded absorptions are, however, not known.

For a knowledge of the sequence of the various molecular states and which of them have an energy curve with a minimum, Heitler and London[51] approach the problem from the limiting case of the separate atoms. They consider the two constituent atoms in given stationary states, when infinitely distant, as the starting point of a perturbation calculus and investigate how the energy of the system changes with the approach of the atoms. Their results seem to be valid in cases where both the atoms are in the S state ($l = 0$), and may be generalized thus :—

When two atoms having spins s_1 and s_2 are brought together, molecular states are formed according to the ordinary rules of synthesis put forward by Hund.[52] Heitler and London now assert that of these molecular states, the lowest will be one in which the spins compensate each other as far as possible, i.e. a state with resultant spin $S = | s_1 - s_2 |$. Only if such a compensation actually takes place, i.e. if both s_1 and s_2 are different from zero, then will this molecular state have an energy curve $U : r$ with a minimum indicating a stable formation.

Thus in the case of H_2 molecule, the two hydrogen atoms in the S state give rise to $^1\Sigma$ and $^3\Sigma$ states with their spins coupled as $s_1 - s_2 = 0$ and $s_1 + s_2 = 1$, respectively. Of these, the $^1\Sigma$ state gives the stable molecular formation of the ground state and the other gives the repulsive state responsible for the continuous emission spectrum of hydrogen. In helium or in rare gas atoms, the ground state being a ^1S state with $s = 0$, no physically stable molecules are formed.

The rules of Heitler and London are also applicable to cases where one of the atoms is in an S state and the other in a P state. Thus with one of the H atom in the $1S$ state and the other in the $2P$ state, the rules provide two stable states $2\,{}^1\Sigma$ and $2\,{}^1\Pi$. Both of these are known. These rules are not applicable when neither of the atoms is in an S state. For these and generally speaking for all cases, the methods of electronic configurations developed by Hund, Herzberg and Mulliken seem to be better.

THE INTENSITY OF ABSORPTION BANDS.

All the bands belonging to the same electronic transition but of different vibrational transitions form together one band system. The intensity of the band connected with a given pair of vibration levels v'' and v' depends upon two factors :—(*a*) the number of molecules in the initial vibration level v'' of the ground electronic state and (*b*) the probability of the transition to the final vibration level v' of the upper electronic state. In a cold gas most of the molecules are in the minimum vibrational state $v''=0$. Consequently the absorption bands chiefly form one v' progression, namely that corresponding to $v''=0$. The number of molecules in the various lower vibrational states ($v''=0$, 1, 2, etc.) depends on the Boltzmann distribution and consequently when the vibration frequency w_0'' is small, there may be an appreciable number in other states as well. This is the case with the halogen molecules and for this reason they show a number of v' progressions. For molecules for which w_0'' is large, only one progression of bands ($v''=0$) is absorbed, but by raising the temperature, the population of molecules in the higher states ($v''=1$, 2, 3, etc.) can be increased so as to produce the absorption of other progressions, as has been shown to be the case with O_2, NO, CO, etc.

Regarding the probability of transition from one v'' state to another v' state, Franck's idea was that in an electronic transition the instantaneous internuclear distance remains unchanged, so that in the first instant of absorption the molecule passes from a state on a lower potential curve to a state vertically above it on the upper potential curve. Condon [53] extended this idea and asserted that an electronic transition is most likely to occur when the nuclei are in their extreme positions, as they spend more time at these two turning points in each period of vibration. Thus, from a knowledge of the $U:r$ curves of the two states, a qualitative correlation of the intensity distribution in a band system is possible. Experience has shown that an empirical formula proposed by Morse,[54]

$$U=E_e+D_e\left[1-\epsilon^{-a(r-r_0)}\right]^2$$

is good enough for the purpose not only in the case of non-

polar molecules but also in the cases of polar atomic molecules at any rate for such vibrations, which are of importance for this purpose.

That such a picture gives only the most probable transitions and not the whole range of possible transitions, is emphasized by the presence of other bands, which fall beyond the transitions given by $r''_{max.} \rightarrow r'_{max.}$ and $r''_{min} \rightarrow r'_{min.}$. The position is better understood by wave-mechanics, according to which the probability that for a given vibrational energy, the nuclei will be found at a definite distance apart, depends on the value of the vibration function for that state. The probability curve has $n+1$ loops for a level of vibration quantum number n, as shown in fig. 5.

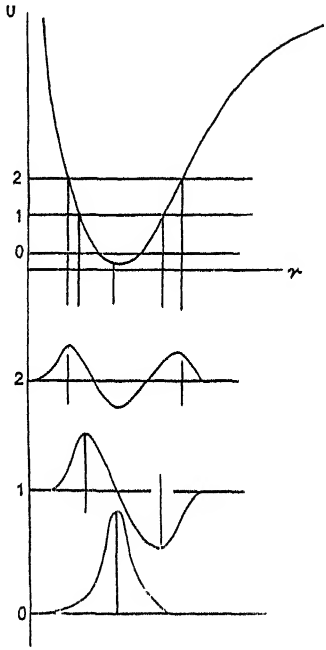


FIG. 5

Thus for the $v''=0$ vibration state transition may occur not merely from a single point on the lower potential curve to a single point on the upper curve vertically above it but from other points as well, giving rise to a v' progression. In other states of vibration ($v''=1$, 2, etc.), maximum probability still occurs at the turning points as in the earlier theory, but probability of transitions from intermediate points also become considerable. The actual intensity of a band is given by the product of the probabilities of the representative points on the upper and lower

curve between which transition takes place. In this way Hutchisson[55] has obtained good agreement with the observed band intensities in certain systems of Na_2, K_2, I_2, etc.

Polarisation molecules.

The possibility of loose molecular formations, due to Van-der-Waal forces between two normal atoms has already been referred to. A number of metal vapours, notably those of Zn_2, Cd_2 and Hg_2, were found to possess continuous absorption (as well as emission) bands. Their association with atomic lines led their interpretation as due to polarisation molecules, whose $U : r$ curve in the ground state have a flat minimum, indicating a loose binding and the excited state a comparatively more rigid binding. The absence of quantization for the vibrational motion in the ground state is responsible for the continuous character of the spectra. Under certain conditions, it has been found possible to detect a structure in these bands, presumably due to the quantization of the ground state, from which Kuhn[56] has deduced the magnitude of the fundamental vibration quantum.

The same applies to certain bands in metal vapours (Na, K, Rb, Hg, In, Tl) in the presence of rare gases, which Oldenburg and Kuhn[57] ascribe to diatomic compounds between the metal and rare gas atoms.

According to the theory of Heitler and London, the Zn, Cd and Hg atoms cannot form molecules, as the ground state is a ^1S state with vanishing resultant spin, which leads to a repulsive interaction. The rare gas atoms have also a ^1S state as the ground state and should not therefore combine with metal atoms. By carrying the perturbation calculus of Heitler and London one approximation further, Eisenschitz and London[58] have shown that at large nuclear distances, the weak repulsive force due to the second stage approximation which still remains, may be balanced by weak attractive forces of the Van-der-Waal type leading to a molecular formation with a flat minimum of the $U : r$ curve. Hence these molecules are ascribed to be due to polarisation molecules or Van-der-Waal molecules.

The existence of such molecules in the case of potassium without the presence of rare gases, has been established in the Presidency College laboratory at Calcutta[59]. The ground state of potassium has a spin other than zero. Hence the repulsive interaction brought about by a non-compensating orientation of the spin vectors ($S = S_1 + S_2$), would lead to a stronger binding with the Van-der-Waal attractive force than in the cases of the previously mentioned polarisation molecules. This may explain the sequence of bands observed in the case of potassium at somewhat higher pressure, indicating the occurrence of more than one vibration level in the ground state.

DETERMINATION OF ENERGY OF DISSOCIATION.

(*a*) *Atomic molecules.*

According to Franck's theory, absorption of light may produce dissociation of the molecule into its constituent atoms, one of which is usually excited and that too when the nuclear binding is less firm in the excited state, i.e. when $r_0' > r_0''$ and $w_0' < w_0''$. Dissociation would also occur if the binding is negative in the excited state giving rise to a repulsive state. The energy of dissociation D' in the excited state can be most accurately determined if the v' progression for $v'' = 0$ can be followed to the convergence limit, where the continuum begins and then,

$$D' = hc\,[\nu_{\text{conv.}} - \nu_{(0,0)}].$$

The energy of dissociation D'' in the ground state can also be determined from $\nu_{\text{conv.}}$ if enough is known about the products of dissociations for both the electronic states. For instance, if the upper and lower electronic states of a molecule AB are formed as: $(AB)' \rightarrow A' + B$ and $(AB)'' \rightarrow A'' + B$, where B, A' and A'' represent the relevant electronic states of the constituent atoms; and if such a molecule dissociates, then,

$$D'' = hc\,.\,\nu_{\text{conv.}} \mp E_{\text{atom}} \text{ or, } D'' = hc\,.\,\nu_{\text{conv}}$$

according as A'' is less or greater or equal to A', as indicated by their $U : r$ curves in fig. 6.

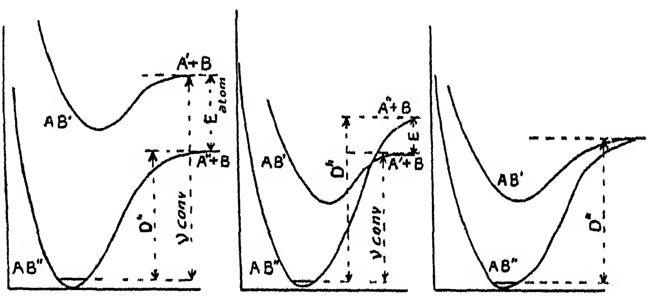


FIG. 6.

Experimentally, however, it is only in few cases that the progression has been followed to the convergence limit, usually the limit has to be determined by extrapolation and unless this is a short one erroneous results are likely to be obtained.

Although in the case of atomic molecules, absorption of light leading to dissociation usually gives a continuous spectrum accompanying the bands, the presence of continuous absorption without the bands must not be taken as an index of the ionic nature of the molecule; for in the case of atomic molecules also this may be obtained, when:—

(1) the binding in the excited state is so loose that $r_0' \gg r_0''$ and consequently the vertical passage from the

fundamental state leads to a point on the upper curve which lies above the limit of dissociation. Such cases are very rare and such molecules may show banded absorption at sufficiently high temperature;

(2) there is no binding in the excited state, which corresponds to a state of repulsion of the atoms brought about by the excitation of one of the atoms. The long wavelength limit of the continuous absorption in these cases correspond to an energy of photo-process in excess of that calculated from the thermal heat of dissociation by an amount equal to the excitation energy of the atom. As the ground state of such a molecule is formed by the spin coupling of two atoms, the excited state must correspond to one of the other multiplet state of the excited atom, caused by a reversal of the spin vector. The cases of hydrogen halides perhaps belong to this class;

(3) in the third category fall those molecules in which the ground state is formed by an excited and a normal atom and the excited repulsive state by two normal atoms.

(*b*) *Ionic Molecules.*

These are molecules in which if the vibrations in the ground electronic state were increased, these would dissociate into two ions with equal and opposite charges. As the ionisation potentials are usually large compared with the electron affinities, the convergence limits of the fundamental states lie very high and their potential curves are usually intersected by those of the excited states. Fig. 7 shows the case of NaI.

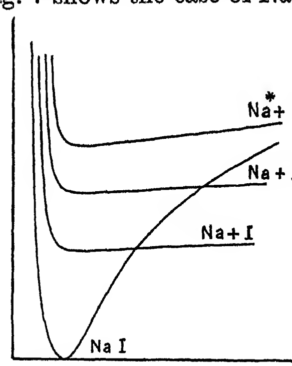
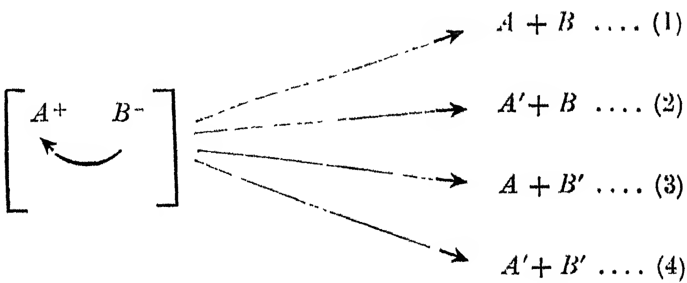


FIG. 7.

The absorption of light primarily transfers the electron from the anion to the cation, thereby creating repulsive states

or states of very loose binding entirely due to Van-der-Waal forces. Thus the following four possibilities of dissociation may arise according to energy input :—



Of these the first three have been realized experimentally, in the spectra of the alkali-halides, which show a number of maxima whose differences correspond to the various stages of excitation of the atoms. Evidence as to this has in many cases been furnished by the fluorescent emission of the characteristic lines of the excited atoms.

The occurrence of more than one region of continuous absorption is spectroscopically the chief criterion of an ionic molecule. The correlation of the term difference of the excited state, according to some authors, is best to be sought between the distance of the centres of maxima and not between their long wavelength limits, as these are more easily affected by the varying conditions of experiments relating to temperature and pressure. Finkelnberg [60] and Sen-Gupta [61] have, however, shown that the inclination of the upper potential curves being different, the difference between the maxima of absorption may lead to considerable errors. For this correlation, it is perhaps best to choose the difference between the long wavelength limits and under such conditions that all the molecules are in the normal state of vibration. In seeking correlation between the thermo-chemical and photo-chemical values, however, it is better [62] to take the long wavelength limit under conditions approaching to those for thermal measurements, i.e. with the absorption tube at room temperature and at atmospheric pressure. Too much stress, however, cannot be laid on the importance of a perfect correlation, as neither the limit can be determined very accurately, nor can any high degree of reliance be placed on the heat of dissociation values, particularly those calculated from considerations of the Born cycle, as many of the data involved in the calculation are uncertain. In any case, in such experiments it is essential to use microphotometric curves with proper corrections of the variation of the density of the plate and the intensity fluctuations of the continuous

source for different wavelengths. Further, it is desirable that in such experiments the light from the source is divided into two beams and made to illuminate different parts of the spectrograph slit, after transmission through one of two similar and narrow tubes, one maintaining a vacuum and the other the gas at the desired pressure. In this way the records for zero and true absorption, which are necessary for determining the percentage of absorption, may be collected at a single exposure. This removes the errors due to fluctuations of intensity of the source which invariably arise at separate exposures, even though the hydrogen discharge tube, which is commonly used as the source, is maintained at a steady condition in all outward appearances. This, of course, requires that the slit of the spectrograph would be accurately uniform throughout.

Determination of fundamental vibration frequency from continuous absorption records.

In the case of the molecules of the alkali-halides, Sommermayer[63] first observed fluctuations of intensity at the long wavelength beginning. Interpreting these as maxima of the probability of transition and assuming that the inclination of the upper potential curve is negligible, he asserted that the distances between the fluctuations give the vibrational quantum of the fundamental state. In this way he obtained values of fundamental vibration frequencies which were in agreement with those calculated by Born and Heisenberg[64] and by Van Leeuwen.[65]

Recently, we have succeeded in obtaining similar fluctuations of intensity at the long wavelength beginning of HBr, HCl and N_2O. The fluctuation is rather feeble and this is what is expected, for the fundamental vibration frequencies being large the population of molecules in the first quantum state ($v'' = 1$) is rather small. In our observations, however, plotting the fluctuations as originating from two separate absorption curves, the distance between their long wavelength limits gives very good agreement with the accepted values of the vibration quanta of HBr and HCl. The value obtained for N_2O is not available for comparison. By careful microphotometric analysis of continuous absorption records for varying pressures, the method is likely to yield the value of the fundamental vibration quanta of such molecules which do not show any band spectra from which such determinations are possible.

It has been contended[66] that consistent with the validity of the Condon's principle, this explanation requires the upper curve to be very nearly horizontal from the point P vertically above the point representing the maximum of the vibration wave-function of the fundamental state of the lower curve. The long extension of continuous absorption on the short wave-

length side, however, requires that the upper curve would be fairly steep on the left of P. The upper potential curve has thus to be given somewhat unusual shape as shown in fig. 8.

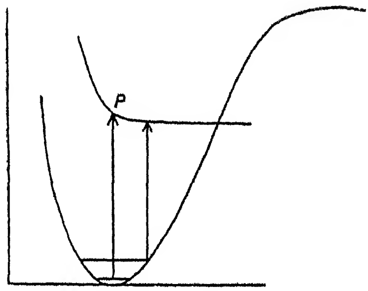


FIG. 8

Without making the form of the upper curve horizontal to the right of P, attempt at obviating this difficulty has been made by Trivedi by choosing a suitable form of the repulsive potential, so that for dissociation the molecule need not be raised to the upper curve but only to its asymptote. Physically, such a process seems to be very improbable. An explanation is possible by wave-mechanics. For, according to wave-mechanics the internuclear distance corresponding to any vibration energy level is not limited by the intercepts of the $U:r$ curve but is represented by a probability curve, which extends beyond the $U:r$ curve, as shown in fig. 9 below :—

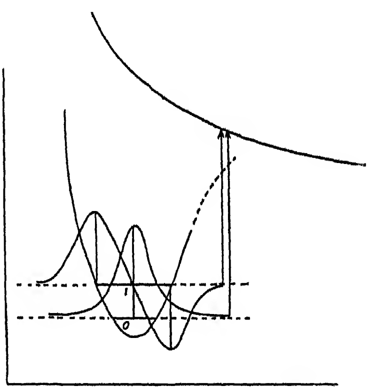


FIG. 9

This makes it possible that at the long wavelength limit (represented by the arrows), corresponding to transitions from the states $v'' = 0$ and 1, the points reached on the upper potential curve are practically on a horizontal line, although the form of the upper curve has no unnatural features. It is of course true that the probability of such transitions are extremely small,

but then it has to be remembered that the fluctuations of intensity are observed only at comparatively high pressures and those again are very weak. Until more number of accurate observations are available regarding the range and intensity distribution of the continuous absorption spectra a satisfactory theory giving the form of the repulsive state can hardly be expected.

Mention, however, may be made of an interesting method of calculating the form of the upper potential curve from the eigenfunction of the ground state and the experimentally observed extinction coefficient by Goodeve and Taylor.[67] They have shown that

$$\log_e \epsilon_{\max.} - \log_e \epsilon_\nu = 2\beta(r - r_0)^2.$$

According to their views, maximum values of ϵ correspond to transitions from the equilibrium separation of the atoms constituting the molecule. Light of other frequencies can also be absorbed when the atoms are displaced from this equilibrium position, the corresponding extinction coefficient being a function of the displacement. A plot of a part of the upper potential curve is thus possible by determining r from the observed extinction coefficient at maximum and at any other frequency ν. An empirical equation is then made to fit with the experimentally determined curve and from the constants of the empirical equation so derived, the full curve is drawn. Following this method the authors have succeeded in calculating the energy of dissociation of HBr and HI, which they find to correspond to an atomic binding.

Dissociation of poly-atomic molecules.

Extension of Franck's ideas of the dissociation of diatomic molecules by absorption of light to poly-atomic molecules, was first made by Saha and A. K. Dutt[68] in explaining the absorption spectra of saturated halides, such as CCl_4, $SiCl_4$, $TiCl_4$, and $SnCl_4$. On the assumption that these molecules are ionic and the effect of light is to transfer one electron from the anion to the cation, so that one of the Cl atoms gets detached, they succeeded in showing that in the cases of CCl_4 and $SnCl_4$, where sufficient data were available for calculating the atomic heat of formation R, the long wavelength limit of absorption coincided with $R/4$, as if the total heat of formation is equally distributed amongst all the four X-Cl bondages. This led them to make a general observation that in the case of a saturated poly-atomic molecule $R/n = h\nu$, where ν corresponds to the long wavelength limit of continuous absorption and n is the number of halogen atoms. Although subsequent observations did not confirm the empirical relation in many cases, the main contention of the authors is possibly true, but very

likely owing to the influence of the Cl atoms upon one another, experimental verification has been difficult. Considering the uncertainties of the determination of the long wavelength limit and of the data relating to calculation of atomic heats, a satisfactory generalization does not seem possible at present.

PREDISSOCIATION.

While considering the possibilities of dissociation of a molecule by absorption of light, the picture will be incomplete if no references are made about the phenomenon of predissociation first observed by Henri[69] and his pupils in the case of sulphur and now recognized as a perfectly general feature of the absorption bands of both di- and poly-atomic molecules. The phenomenon is noticeable as an abrupt change of appearance of the rotational lines at a certain point in the v' progression. The rotational fine structure, which is sharply defined in bands of lower values of v', suddenly become diffuse and blurred at values of v' higher than a critical value. The non-quantization of the rotational energy was recognized by Born and Franck[70] as due to a shortening of the life-period of rotation due to the occurrence of radiationless transition from the upper electronic state B, for the system $A \rightarrow B$, to another electronic state C (fig. 10), resulting in dissociation. The bands which appear diffuse in absorption are entirely absent in emission. This definitely suggests dissociation. While according to Franck's idea, these transfers should set in at a definite rotational level of a particular band of v' progression, viz.: that corresponding to the point P, the wave-mechanical theories due to Kronig[71] allow of transitions not only at P but also at points on the curve B close to P, of course with lesser probabilities. This explains the diffuse appearance of the entire rotational lines of the particular band.

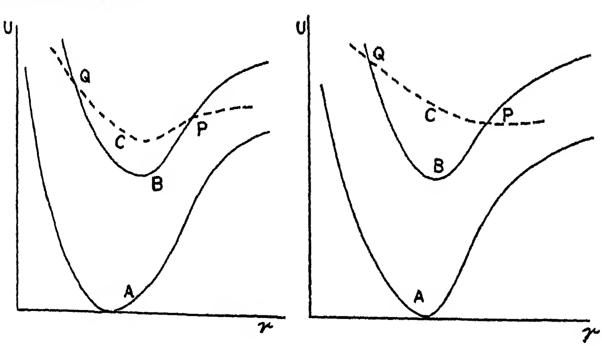


FIG. 10

For non-radiating transitions considered above, it is not enough that a third electronic level C, leading to dissociation,

should co-exist but several other conditions have to be fulfilled. These are : (1) the two levels must have the same value for the total angular momentum, (2) they must belong to electronic states in which the angular momentum of the electrons about the line joining the nuclei do not differ by more than one unit, (3) they must also satisfy certain other properties of symmetry of the corresponding wave-functions.

In many cases, particularly in the S_2 band system, there is another predissociation at Q, beyond the one at P, where the band becomes still less sharp. In such cases there is a double cut of the B and C curves, as in the figure. The curve C may or may not represent a stable molecular formation. In the case of S_2 it is of the latter type.

A rise of temperature displaces the limits of predissociation towards the long wavelength side. The greater the molecular heat of the substance, greater is the temperature displacement. In the case of benzene, the displacement actually observed is in good agreement with the increase in the kinetic energy of the molecules by an amount $C_v(T_1-T_2)$, where C_v is the specific heat of the gas. The temperature effect thus suggests some sort of energy adjustment in the molecule subsequent to absorption.

Colours of inorganic salts.

An interesting speculation as to the possibility of explaining the colours of inorganic salts due to the spin vector being reversed by the absorption of light has been attempted by Saha.[72] Colours are almost entirely shown by the compounds of the transitional group of elements. Saha has developed the view that in this class of salts, intrinsically the colour is due to the cation. The absorption of light in the visible region, which is responsible for the colour, being due to one of the $3d$ electrons in the cation changing its s vector from $+\frac{1}{2}$ to $-\frac{1}{2}$. Thus in the case of $CrCl_3$—($Cr^{+++}Cl\ \ Cl\ \ Cl$), the ground state is obtained by adding all the s vectors giving the terms ^4F and ^4P ; the absorption of light reverses one of the s vectors giving the metastable terms ^2H, ^2G, ^2D. The average difference in the energy between the terms of the fundamental and the metastable state correspond to the energy of the light absorbed by $CrCl_3$ vapour. Bose and Datta[73] have extended Saha's ideas in hydrated paramagnetic crystals showing the influence of the solvent dipole molecule in shifting as well as producing a broadening of the line. Thus, although the solid crystals may show a broad absorption, there is very little doubt that in these classes of molecules the mechanism of colour production is due to light causing a change of the spin vector.

Discovery of rare isotopes.

In the case of band spectra, the influence of nuclear mass is very great, since it affects both the moment of inertia and the

vibration frequency of the molecule. There should therefore be a considerable separation of the band spectra of two isotopic molecules. This was first suspected by Imes[74] in 1919 from the asymmetrical shape of the absorption curves of the lines of the HCl infra-red band at $1{\cdot}76\mu$. The HCl^{35} and HCl^{37} bands have now been completely resolved by Meyer and Levin.[75]

In 1923–25, Mulliken[76] discussed the theory of the isotope effect in detail and obtained confirmation of the theoretically predicted effects in electronic band systems of several molecules, e.g. BO, CuI and SiN. Recently, however, study of absorption has led to the discovery of isotopes, which have eluded the mass spectrograph, the most notable being those belonging to oxygen and nitrogen.

From the study of the red absorption bands of O_2, Giauque and Johnston[77] succeeded in discovering the isotopes O^{18} and O^{17} as represented by a number of weaker bands associated with the main bands. The observed separation of these lines from the main line is in perfect agreement with the calculated isotopic shift. The intensity measurements of these band lines by Mecke and Childs[78] show the relative abundance of the three isotopes to be $O^{16} : O^{18} : O^{17} = 630 : 1 : \frac{1}{5}$.

Nitrogen isotope N^{15} was discovered by Naude[79] from a study of the γ bands of NO in absorption. Between two corresponding band heads of the molecules $N^{14}O^{17}$ and $N^{14}O^{18}$, there occurred a third band which agreed with the calculated position of $N^{15}O^{16}$. Comparisons of intensities of these bands has led to the abundance ratio of the isotopes $N^{14} : N^{15} = 346 : 1$.

Applications of absorption spectroscopy.

An attempt has been made in the foregoing sections to give a brief sketch of some of the various aspects of absorption studies in the elucidation of the problems of atomic and molecular structure. In concluding the address, it would perhaps not be out of place to make a passing reference to some of the various applications of absorption spectroscopy.

The alluring hypothesis, which postulates that no two substances exhibit precisely the same absorption spectrum, has led to the use of this method to an exceedingly wide range of industrial and medical purposes, some of which may be mentioned.

The absorption spectrum of blood sera has been investigated in the hope that divergence in the form of the curves relative to pathological sera would help in the diagonosis of the disease. The quest has been made not without some success. Comparison of the absorption curves of normal blood with those from typhoid patients revealed a shift of the minimum of absorption by about 30 Å. The shift though slight was well defined and was found only in those cases where the bacteriological evidence indicated the presence of typhoid germs.

The identification of dyes of all types is another very useful application. No two dyes have identical curves and careful spectrophotometry provides the best means of determining the constituents of mixtures of dyes.

Like the dyes, the alkaloids give very clear definition of their absorption spectra. The form of the curves identifies the alkaloid and the extinction coefficient determines the quantity present.

Glass is another substance which, by reason of its nature and diversified use, has been the subject of close absorption test. Cinematograph films and other transparencies have also received attention, as also artificial silk-fabrics in connection with their allowing ultra-violet rays to pass, with the object of ascertaining how far they are of advantage in bodily hygiene.

Lastly one must not forget the important contribution which the absorption studies have rendered in the detection of vitamin A and the help generally given in the matter of determination of the chemical nature, the concentration and assay of vitamins.

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SECTION OF MATHEMATICS AND PHYSICS

Abstracts

Astronomy and Astrophysics

1. On the gravitational stability of a nebular system.

N. R. SEN, Calcutta.

A large nebular mass may become unstable owing to the gravitational pull on any of its parts being too weak to counteract the dissipative tendency due to what is called cosmic repulsion. De Sitter made a rough calculation to see how a balance between the two opposite tendencies within a spherical nebular mass can be reached. In this paper the escape velocity of a particle near the boundary of such a mass is calculated under certain simplified conditions. It is found that for Hubble's estimated mass of our galaxy e.g. $M = 2 \cdot 10^9 \odot$, the outlying portion of such a nebula without rotation has an escape velocity of the order of only 25 km/sec. The outer portion of such a nebula is thus likely to contain much unstable material. On the other hand a higher value for the mass e.g. $M = 10^{11} \odot$ would raise the value of the escape velocity to one of order 200 km/sec.

2. The neutron mass and degeneracy.

D. S. KOTHARI, Delhi.

The mass of the Neutron is greater than the combined mass of the proton and the electron by an amount of about 0·01 mass units. This has a very important consequence on the equation of state obeyed by *degenerate*-matter—degenerate in the sense of Fermi-Dirac statistics.

If a mixture of degenerate matter, for example, protons and free electrons, be gradually compressed, there will be an increase in the value of E_{max}; E_{max} being the maximum energy for the degenerate electron gas ($E_{max} = \frac{5}{3}$ times the mean energy). When E_{max} attains the value of 0·01 mass units ($1 \cdot 48 \times 10^{-6}$ ergs), then the degenerate gas will contain electrons with this energy, and these electrons will be able to transform protons into neutrons, the neutrinos being furnished from negative states. On further compression E_{max} will not increase any more, for any electron having an energy greater than 0·01 mass units will be absorbed by a proton to form a neutron. This limiting value for E_{max} corresponds to a density of about 10^7 gms. per c.c. Hence, the pressure of the degenerate electron gas will not exceed a certain limiting value. At this limiting value since the *non-relativistic* equation of state continues to hold fairly well, the *relativistic* equation has no application in practice. These results lead to very significant astrophysical consequences, and suggest a possibility of determining neutron-proton mass difference from Astrophysical observations.

3. Annihilation and stellar structure.

B. SEN GUPTA, Calcutta.

A quantitative investigation following the recent theory of Prof. Milne on stellar structure, on the physical properties of a two-phase

stellar model is carried out; the core satisfies Emden's equation of polytropic index n_2 tending to infinity, which is the case when the phenomena of creation and annihilation of matter is taking place in the core in statistical equilibrium, and the envelope satisfies Emden's equation of polytropic index n_1 equal to three, that is when in the envelope the equation of state in the matter is that of a perfect gas. The possible identification of these model stars with those actually existing in nature is discussed.

4. Effect of magnetic field on the behaviour of an ionised gas.

R. C. MAJUMDAR, Calcutta.

In the first part a general theory on the conductivity of such a gas by taking into account of the quantisation on the motion of electrons in magnetic field is developed. The application of the theory is also discussed in reference to the turbulent motion in the sun's atmosphere. The second part is devoted to explain the cause of variation as well as limitation of the intensity of sun's magnetic field with height from the Photosphere, as observed by Hale and his co-workers in the Mount Wilson Observatory. An attempt is also made to explain the origin of the phenomena of the sun's spot.

5. Note on the blink comparator of the Nizamiah Observatory.

T. P. BHASKARA SHASTRI *and* M. K. BAPPU, Hyderabad.

A comparator for comparing two photographs of the same region of the sky has recently been acquired for the observatory. A detailed description of the instrument is given, and also of the blinking device which is designed to be operated by shutters worked by hand. After some preliminary trials, the comparator has been brought into regular use; it is now employed in the comparison of the new series of repetition plates that are being obtained with the photographic equatorial, with the plates of the old series taken about twenty years ago for purposes of the Cart du Ciel Catalogue. The comparison is expected to yield all proper motions exceeding six seconds per century among the faint stars of the Catalogue. Some of the results obtained are summarised in this note.

6. The proper motions of the reference stars in the Hyderabad astrographic zones.

M. V. VAIDYANATHA SASTRI, Hyderabad.

The reference stars for the Hyderabad section of the Carte du Ciel were selected from the Catalogues published by the Algiers and Lund Observatories from meridian observations. For obtaining the plate constants the measures on the Hyderabad plates have been compared with the positions (Standard Co-ordinates) computed from the places given in these Catalogues. A number of stars were found, during comparison, to have sensible proper motion and so had to be excluded from the equations for deriving plate constants. The proper motions exceeding 10″ per century have been arranged and discussed in the present note. A value for the apex of the solar motion has also been obtained, which is in good accordance with the results from material extending over larger areas in the sky.

Magnetism

7. Magnetic studies of ionic deformations.

S. RAMACHANDRA RAO *and* K. C. SUBRAMANIAM, Annamalainagar.

In covalently linked chemical compounds, the additive law of ionic susceptibilities is found not to hold good, the observed susceptibilities being lower than the additive values. This has been attributed to ionic deformations in the compounds, such deformations contributing a paramagnetic component which in effect decreases the susceptibilities of the molecules. The extent of deviation from the additive law gives a measure of the deformations of the cations and anions. Fajans has shown that the deforming power of a cation is larger, the smaller its size and greater its charge. On the other hand, anions suffer greater deformation when they are large in size and possess greater charge. The ions possessing inert gas configuration however produce or suffer less deformation than those that do not possess such closed configurations. Magnetic investigations on the halides of zinc, cadmium and mercury in the solid, liquid and dissolved states support these conclusions. The magnetic data are in agreement with the results obtained from studies of electrical conductivity, optical refractivity and Raman effect.

8. Secondary electron emission at the Curie point of nickel.

S. RAMACHANDRA RAO, Annamalainagar.

The investigations of Tartakowsky and Kudrjawzewa and Hayakawa indicate the existence of an abrupt variation of the secondary electron current at the Curie point of nickel (358°C). The author has shown that the photo-electric efficiency for soft X-rays of nickel does not alter at the Curie point. The soft X-ray intensity at a given applied potential was also found to show no abrupt variation at the Curie temperature. These conclusions suggested that the increase in the secondary emission at the Curie point should be due to an increase in the number of electrons returning with the same velocity as the primary or with a slightly decreased velocity. Experiments on the energies of the secondary electrons by the retarding potential method confirm the above conclusion. This would suggest that the energy of the structure electrons responsible for the conservation of spin in the microcrystals of Heisenberg decreases suddenly to very low values at the Curie point. This would explain the disappearance of ferromagnetism and the observed increase in the secondary emission.

9. Magnetic susceptibilities of single crystals of cadmium.

S. RAMACHANDRA RAO, Annamalainagar.

Single crystals of cadmium were prepared by the method of slow cooling and the principal magnetic susceptibilities determined by Guoy's method. The susceptibility parallel to the hexagonal axis (χ_{11}) was found to be 0·242 while the value perpendicular to this axis (χ_{1}) was 0·155. The mean susceptibility for a polycrystalline aggregate works to 0·184. These values agree satisfactorily with those of Maclennan, Reudy and Cohen. From the known susceptibility of Cd^{+2} ions, it can be inferred that the binding parallel to the *c* axis is metallic. Crystals subjected to tensional forces beyond the elastic limit showed very small variations in the values of χ_{11} and χ_{1}. Cold-working does not seem to have therefore any effect on the principal susceptibilities of cadmium crystals. The effect of introducing small quantities of metals like zinc and lead is to decrease the magnetic anisotropy in all cases.

10. A magnetic study of the mixed crystals of silver halides.

K. N. MATHUR *and* PARMANAND SHARMA, Lucknow.

The emulsion in a fast photographic plate contains silver bromide with a certain amount of silver iodide. The increase in the sensitivity of a silver bromide emulsion brought about by the addition of silver iodide has formed the subject matter of considerable researches. None of the methods so far employed have given any indication as to why the sensitivity of an emulsion increases to a maximum when the amount of silver iodide in a silver bromide emulsion reaches about 5 mols per cent., and then falls again as the amount is further increased. As the magnetic properties are capable of giving more certain indication of internal strains and distortions in crystals, it was considered desirable to investigate systematically the mixed crystals of the silver halides. The magnetic susceptibilities have been determined using a Bhatnagar-Mathur balance, but without the optical interference arrangement. The investigation has yielded very interesting results a discussion of which is presented in the paper.

11. A magnetic study of the association of certain organic substances in solution.

K. N. MATHUR, N. K. MUNDLE, *and* D. G. SANE, Lucknow.

In the present investigation, the molecular association of naphthalene, phenanthrene, triphenylmethane, etc. has been studied when they are dissolved in organic solvents like hexane, benzene, etc. The susceptibilities of the solutions were determined using a balance of the Decker type. The range of concentrations varied from ·05N to 1N. It has been found that in most of the solutions examined the susceptibility of the solid salt calculated from the solution varied considerably with the concentration. This change gives a measure of the degree of association of the dissolved molecules.

12. Studies on constant paramagnetism.

D. P. RAY CHAUDHURI *and* P. N. SEN GUPTA, Calcutta.

A number of paramagnetic substances of which the magnetic susceptibility depends slightly on temperature has been studied with respect to the variation of susceptibility with temperature and the atomic susceptibility for the magnetogenetic atom determined at room temperature. The same has been extended to diamagnetic substances containing elements of the transition series. It is found that the atomic susceptibility is not a constant for the element in question, but varies from compound to compound and depends on the intra-molecular field. The current theories for the origin of such constant paramagnetism are discussed. It is shown that there is no difference in kind between the polarisation theory and Van Vleck's theory of high frequency matrix elements.

13. Variation of diamagnetic susceptibility of sodium chloride with temperature.

D. P. RAY CHAUDHURI *and* P. N. SEN GUPTA, Calcutta.

Sodium chloride which is a standard diamagnetic, is expected to have a constant magnetic susceptibility with temperature. But the present authors find that the susceptibility diminishes slightly in value above 250°C. Such change appears to be structure sensitive to some extent. The effect is sought to be explained by the formation of U centres, which are believed to be sodium atoms.

14. Magnetic susceptibility of vanadium sulphides.

D. P. RAY CHAUDHURI *and* P. N. SEN GUPTA, Calcutta.

In most standard works on magnetism values are given for the magnetic susceptibilities of vanadium sulphides which are not in agreement with the current theory of magnetism for elements of the first transition series. Magnetic susceptibilities of VS, V_2S_3 and V_2S_5 have been determined afresh with special care as regards the purity of the material and it is found that the results are in agreement with the current theory.

Mathematics

15. On the motion of a deformable body through a fluid medium.

S. K. BANERJI, Poona.

The equations of motions of a deformable body through a fluid medium are well known, but it does not appear that any concrete case has been completely solved. If $F(x, y, z, t)=0$ be the boundary equation of the deformable body at any time t, then $DF/Dt=0$. Also if $P(x, y, z, t)=$ const. be the equation of an equi-pressure surface the surface moves in such a way that $DP/Dt=0$, or, in other words, if ∂n be an element of normal to the equi-pressure surface, the velocity of any point of the surface is $-\left(\frac{\partial P}{\partial t}\Big/\frac{\partial P}{\partial n}\right)$. A moving deformable body continually deforms itself so as to obtain ultimately equality of pressure at every point of its surface. From all these considerations a method is deduced by which the successive forms of the body can be traced. The case of a deformable body which is initially a sphere is worked out in detail. It is shown how the front convex surface gets first flattened and then becomes concave and how the rear gets elongated and how finally the body winds itself up as a vortex ring.

16. Mathematics of weir designs.

N. K. BOSE, Lahore.

Weirs and dams form the most important engineering structure in any irrigation system of a country. Up till now designs for these were principally based on Bligh's theory of Creep. This theory, professedly empirical, had been found defective by the engineers all over the world. A new theory for Weir design, which has been verified by experimental observation in the laboratory and in the field, has been developed by the author.

17. On a vibrating string loaded at several points.

D. N. SEN *and* R. KUMAR, Patna.

In text books on Hydro-dynamics, the case of a vibrating string loaded at one point has been considered, and it has been shewn that in the symmetrical case, the frequencies of odd order are diminished. The object of this paper is to discuss the case of a string loaded at several points and to deduce similar result as above for the symmetrical case. In the case of n loads, a determinant of the n^{th} order for the frequency is obtained and it is shown that the roots of this determinant in the symmetrical case are given by $2\cos\frac{\pi r}{n+1}$, $1\leqslant r\leqslant n$, and corresponding to each root a frequency is obtained which is less than the corresponding natural frequency.

18. On space times without matter in the relativity theory.

C. Racine, Trichinopoly.

Under certain very general conditions the gravitational equations of Einstein can be divided into two groups so that the partial derivatives of the second order with respect to time of the potential functions are only contained in the first group. Therefore the second group can be called the system of the initial conditions.

In the present paper I determine the conditions of complete integrability of that second system when the initial space section is extremal. I thus obtain two different types of structure of the space sections. They enable me to build examples of closed space sections which generate gravitational space-times without matter or electricity. I had already proved the existence of such space-times but only when they were homeomorphic to the four dimensional Euclidean space. The examples studied in this paper are varieties whose first number of Betti is greater than zero.

19. A note on the relativistic problem of two bodies.

J. Ghosh, Calcutta.

The problem of two bodies in the general relativity theory is rigorously insoluble because of the non-linearity of the gravitational equations. Approximate solutions have been investigated (e.g. Eddington, Math. Th. of Relativity, Art. 44) with special reference to the motion of the moon under the joint influence of the sun and the earth, by D. Sitter (M.N.R.A.S., Vols. 76, 77). None of the static solutions investigated by Friedmann, Lemaitre and others deals with the two-body problem. So far as the theoretical investigation is concerned, it has been limited to the static solutions and the approximate solutions involve several fundamental assumptions, including: (1) the terms $\beta^2=\frac{v^2}{c^2}$ and $\nu=\frac{V}{c^2}$ ($v=$ the velocity of the moving body, V=Newtonian Potential, c=velocity of light) being of the order 10^{-8}, are neglected; (2) quantities of the order $(D/R)^2$, (where D is the linear dimension of one of the moving bodies and R is the distance between them) are neglected; (3) the possible rotational motion is ignored; (4) the centre of mass of the body is assumed to be the centre of gravity of the body. The author shows in this paper that the assumptions (2) and (4) are not justifiable except in very special cases. He also investigates the Lagrangian function corresponding to the motion of the centre of gravity.

20. On operational representations of the functions of the confluent hypergeometric type.

S. C. Dhar, Nagpur.

Operational method is now very often used to study the properties of various functions. A general account of these is given by Jeffreys (Camb. Tracts. No. 23).

Vander Pol (Phil. Mag. 8, 1929) has recently given a method by which linear differential equations with variable coefficients can be solved by the operational method. By applying it to Bessel's equations he showed how easily all the properties of that function can be obtained.

In a recent paper published by the author in the Phil. Mag. vol. 21, 1936, some new relations and integrals have been obtained by the application of Pol's method to Whittaker and other functions. In this paper the operational representations of M-functions of the confluent hypergeometric type has been obtained in the form of hypergeometric functions

and from the known properties of the latter several new relations and integrals of the former have been deduced.

21. On extension of certain interpolation formula in finite differences to the case of two variables.

P. N. DE *and* P. N. DAS-GUPTA, Patna.

An interpolation formula was given by Newton with divided differences for the evaluation of the function $f(x)$ whose value is known for the values $x_1, x_2, x_3, \ldots x_n$ of the variables. This involves a remainder term $R_n(x)$. In the present paper an extension of this theorem to the case of a function of two variables (x, y) is given, it being provided that the functional values at the points (x_1, y_2), (x_2, y_2), (x_2, y_3), (x_3, y_3) are known.

22. On combined invariants of some covariant quatrics of a system of two quaternary quadrics associated with two linear complexes.

N. CHATTERJEE *and* P. N. DAS-GUPTA, Patna.

Weitzenböck has considered the invariants and covariants system of a single quaternary quadric associated with two linear complexes (Journal fur Math. 137, 1910). The complete system which includes linear complexes and mixed concomitants of a quadric with two linear complexes has been discussed by one of us elsewhere (Proc. Lond. Math. Society, ser, 2, Vol. 31, part 7). In a recent paper (July No. 1936 of the Cal. Math. Soc. Bulletin) the corresponding irreducible system has been discussed by us. In the present paper three simpler covariant quadrics of the system detailed by us are associated with one of the given quadric to yield combined invariants whose forms are worked out in terms of irreducible invariants of the system.

23. On the zeros of generalized Jacobi polynomials.

D. N. SEN *and* V. RANGACHARIAR, Patna.

The differential equation. $(\alpha x^2+\beta x+\gamma)y_2-(x+a_1)y_1+\{n-n(n-1)\alpha\}y=0$, where n is a positive integer, has polynomial solutions Y_n of degree n. In a paper by the authors, accepted for publication in the Bulletin of the American Mathematical Society, some properties of Y_n have been obtained and the number of roots of $Y_n=0$ in (a, b) for certain values of n have been obtained, (a, b) being the roots of $\alpha x^2+\beta x+\gamma=0$). The object of the present paper is to determine the number of roots of Y_n $=o$ *for all values of* n in the ranges $(-\infty, a)$, (a, b), (b, ∞). In the range $(-\infty, a)$ there will be either one or no root of any of these. A similar result will be true for the range (a, b) up to a certain stage after which the number of roots goes on increasing by 1. In (b, ∞) there will be, in general, a stage up to which there will be no root, followed by a stage of increase in the number of roots and then by a gradual decrement up to zero; after this the number of roots will be either one or zero. It is also seen that after a certain stage (earlier than what was given in the paper mentioned above), the number of imaginary roots remains constant.

24. The three orthogonal congruences of curves.

V. RANGACHARIAR, Patna.

In a paper ' On Curvilinear congruences ' by Dr. C. E. Weatherburn, published in the Transactions of the American Mathematical Society, Vol. 31 (1929), it has been proved that for three orthogonal congruences of curves. the moments of any two of the congruences in the direction of

the third are equal. In the present paper the same result has been obtained by a different method and also expressions for the moments and the tendencies have been obtained in terms of torsions, curvatures, normal angles and the rates of changes of these normal angles.

25. Remark on Peano's curve.

A. N. Singh, Lucknow.

The method given by G. Peano in his paper published in the Mathematische Annalen, XXXIX, p. 157, can be modified to prove the following theorem :

There exists an aggregate of functions of a real variable, $f_n(t)$ ($n=1, 2, \ldots m$), defined and continuous for $0 \leqslant t \leqslant 1$, and satisfying the inequalities $0 \leqslant f_n(t) \leqslant 1$ for $n=1, 2 \ldots m$, and such that whatever the real numbers $a_1, a_2, a_3, \ldots a_m$, $0 \leqslant a_n \leqslant 1$, may be, there always exists at least one real number t, such that

$$f_n(t)=a_n \text{ for } n=1, 2, \ldots . m.$$

In the present paper I give a method according to which the functions $f_n(t)$ can be easily obtained.

26. Ellipsoidal wave-functions. Part II.

S. L. Malurkar, Agra.

The paper is a continuation of the earlier memoir (see *Ind. Jour. Phy.* vol. IX, p. 45–80) and deals with the preliminary theorems required in connection with the expansion of an arbitrary function of three variables in terms of the characteristic Ellipsoidal Wave-Functions. The region of convergence of such an expansion is also considered.

27. Some asymptotic expansions in Lamé functions.

S. L. Malurkar, Agra.

The methods employed in connection with Ellipsoidal wave-functions have been applied to Lamé functions and interesting results have been derived. The constants of the functions and the regions of applicability have also been considered.

28. On the differential equations of the criteria of instability.

S. L. Malurkar, Agra.

The sixth order differential equation for the discussion of Instability derived by Jeffreys was solved by him by method of finite differences and later by taking a Fourier sine series for the sixth derivative of the dependent variable and by successively integrating to obtain lower derivatives. Low solved the equation directly based on the roots of $x^3=1$. The author has dealt with another direct method of solving the equation where the final results are the same as those obtained by Jeffreys. The method can easily be applied to more general equations of instability which cannot be attacked by the previous methods.

29. On the criterion of instability of thin layers of air when the lower layers have more moisture content.

S. L. Malurkar, Agra.

Rayleigh, Jeffreys and Low have determined the criteria of instability that is produced in a thin layer of fluid when the lower surface is heated under different boundary conditions. Instability or top-heaviness can be brought about in a thin layer of air by injecting moisture to the lower layers. The problem is to determine whether there is any criterion

to limit the degree of top-heaviness. It is shown that the function usually known as the *mixing-ratio* follows equations similar to those obtained for temperature in equations of convection. It is deduced that the criterion can be put as

$$\frac{\rho_1-\rho_0}{\rho_0} < K \frac{k\nu}{gh^3}$$

where K is a constant depending on the boundary conditions that have been chosen, k is diffusivity, ν is viscosity, $\rho_1-\rho_0$ is the difference of density between the top and bottom layer, ρ_0 is the density at the bottom layer and h is the thickness of the layer.

30. On the polygons formed when any liquid-sheet breaks up into cells.

S. L. Malurkar, Agra.

From purely geometrical considerations it is deduced that when an unsheared liquid or fluid breaks up into symmetrical polygonal cells, the possible forms are only—

(*a*) Equidistant parallel bands,
(*b*) Regular hexagons,
(*c*) Squares, and
(*d*) Equilateral triangles.

Meteorology

31. Day to day variability of the intensity of the earth's magnetic field and its diurnal variation.

K. R. Ramanathan *and* P. K. Achan, Bombay.

Day to day changes of the daily means of horizontal intensity of the earth's magnetic field were utilised by Dr. Moos for a study of terrestrial magnetic activity. Dr. Bartels has in recent years investigated the subject in great detail.

In the present paper, it is shown that the variability is very different if instead of using daily means as in past work we use values at different hours of the day. The variability is found to be a minimum if we consider values at 5 hrs. local time, increases to a maximum when the time is midday and decreases gradually thereafter. There is evidence of a secondary maximum at 19–20 hrs. local time. The results are discussed with reference to the ionisation of the upper atmosphere.

32. Seismic waves from selected 'near' earthquakes in India and adjoining countries.

P. A. Salvi, Bombay.

About a dozen well recorded earthquakes in India and adjoining countries have been analysed by a reference to the seismograms of the three stations, Bombay, Agra and Calcutta (Kodaikanal being far removed from the region of the belt) after determining the epicentre as accurately as possible. It is noticed that besides the main P and S waves with velocities of 7·8 km/sec. and 4·3 km/sec., velocities of 6·3 km/sec., 5·6 km/sec., 3·7 km/sec., 3·3 km/sec. are definitely identifiable. These velocities agree fairly closely with the values of velocities found by Jeffreys and others in the Basaltic and Granitic layers suggesting that the structure of the earth's crust in North India is similar to the structure found for Europe. The determination of the thickness of the layers would require increase in the number of observing stations, particularly in North India.

33. Atmospheric electric conductivity and air-earth current at Colaba.

S. M. MUKHERJI, Bombay.

Measurements of the electrical conductivity of the atmosphere carried out with Gerdien Conductivity apparatus at the Colaba Observatory during the period July 1935 to August 1936 are discussed together with the simultaneous measurements of the atmospheric electric potential gradient obtained with a Cambridge photographic recording Electrometer. In the months October to April high conductivities and low potential gradients occur simultaneously and vice-versa. During the months May to September, the diurnal variation of potential gradient is not well marked but the conductivity shows markedly smaller values during day than during night. Two minima in conductivity occur in the season one at about the time of sunrise and another near sunset.

The diurnal maximum of potential gradient observed during the ocean voyages of "Carnegie" in different parts of the world was also pronouncedly recorded at Bombay occurring at the same time (19 hrs. G.M.T.) in all the months of the year.

Values of mean air-earth current were calculated from the values of potential gradient and conductivity. The mean value of air-earth current is $1{\cdot}5 \times 10^{-16}$ amp/cm.^{2} assuming that the current is carried by positive ions alone. During the monsoon season when the air supply over Bombay is from the sea and when the air-earth current is a maximum, its value is practically equal to the mean current obtained from the ocean observations in the 'Carnegie' but larger than the mean current observed at Kew.

34. The dust-free or dark layer in relation to convection near hot surface.

M. K. PARANJPE, Poona.

The paper discusses the formation of the dark or dust free layer in the air-space between a hot surface (above) and a cold surface (below). The variations of the dark layer (1) with distance between the surfaces when the temperatures of the surfaces are kept unaltered and (2) with the temperature gradient when the distant is kept constant at 3·5 mm. have been studied. It is shown that when the distance between the two surfaces is less than 4 mm. the whole space is occupied by the dark layer. If smoke is introduced into this space it travels from the hot to the cold surface with a velocity proportional to the temperature gradient. The excess of pressure associated with the velocity of the particle is calculated.

35. Study of a storm, which crossed the Madras coast near Nagapatam in November 1935, with the help of synoptic weather charts and sounding balloon ascents at Madras.

S. K. PRAMANIK *and* S. BASU, Poona.

A study of the sounding balloon records which were let off from Madras between the 11th and 19th November, 1935 and afterwards recovered together with the available pilot balloon and cloud observations in the Peninsula has shown that the heavy rain at Madras between the 14th and the 15th was associated with the passage over the station of a front formed between land air of northerly origin with its source probably in northern India and moist north-easterly to south-easterly air from over the Bay of Bengal. The records also throw light on the vertical structure of the atmosphere over Madras before and after the passage of a storm to the south of the station.

The front passed over Kodaikanal on the 15th, where about 14″ of rain, a record fall for the station, were registered between 8 hrs. on

the 15th and 8 hrs. on the 16th. An examination of the autographic charts at Kodaikanal show that the characteristics of this front were similar to those of the tropical front studied by the authors in connection with a storm in November 1931.

36. Some characteristics of a tropical front associated with the storm of November, 1931.

S. Basu *and* S. K. Pramanik, Poona.

An examination of the synoptic situation together with the available records of sounding balloons, viz., those from Hyderabad (Deccan) for the 29th October and 1st and 3rd November indicates that the rainfall at Hyderabad, Poona and Bombay was associated with the passage over or near to these stations of a front between north-easterly land air and south-easterly air from the Bay of Bengal. The records of self-recording meteorological instruments maintained at Poona and Bombay were studied in this connection and the characteristic features of weather marking the approach of these tropical fronts towards, and during their passage over, these stations have been brought out in this paper.

37. An examination of sounding-balloon ascents for a discussion of some aspects of Thunderstorms in Deccan.

S. L. Malurkar, Agra.

From the sounding balloon records collected at Poona, an attempt has been made to study the dynamical aspect of the formation of a thunderstorm. An application of recent work on instability has been attempted. It is found that in addition to the moistures necessary for the development of a thunderstorm, the increase of potential temperature with height was small on days of thunderstorms while on other days the increase was appreciable. As the thermal distribution is not inherently unstable on days of thunderstorms, the causes that would initiate convection have been considered. The thermal distribution is such that it does not inhibit convection once started by extraneous causes. Thunderstorms occur when the air at 2-4 kms is replaced by air potentially colder than what existed there previously or when the lower layer is replaced by air potentially warmer than what existed earlier and sufficient moisture and causes for initiating convection exist.

38. On the temperature distribution near the surface of the ground during afternoons.

S. L. Malurkar, Agra.

In Indian Journal of Physics, Vol. VI, pp. 495–508 the author with Ramdas gave a theory of extremely high lapse-rates near the ground on sunny afternoons by taking into account of radiation from successive layers. The method adopted was fairly elementary. To determine the order of errors that might have crept in and for further progress in the work a more rigorous treatment has been made. It is found that the nature of temperature distribution near the ground as found by theory in the above paper is essentially correct.

39. Variation in the nocturnal radiation from the sky with zenith distance and with time.

L. A. Ramdas, B. N. Sreenivasiah, *and* P. K. Raman, Poona.

The hourly variation of the intensities of the heat radiation coming from different zones of the night sky was measured at Poona on some

nights in April-May 1936 with a Moll's Micro-thermopile and Micro-galvanometer. These observations show that nocturnal cooling of the air layers as indicated by the change in the equivalent black body temperature of the sky is maximum in the first zone 15°–0° (horizontal) and minimum in the zenith 90°–75°. A method of calculating the mean equivalent black body temperature T_s of the whole sky from the zonal measurements has been indicated. The nocturnal fall in T_s as calculated from these observations is of the same order of magnitude as that shown by the Angstrom's Pyrgeometer readings which were also taken simultaneously.

40. Radiation from the night sky on cloudy nights.

P. K. Raman, Poona.

Measurements of the heat radiation from the night sky on a number of cloudy nights are available for Poona for a number of nights during the period 1934–36. The intensity of the radiation in relation to the cloud kind and amount are briefly discussed in the present note.

41. Measurements of nocturnal radiation made at Poona and Sinhagad on clear nights.

P. K. Raman, Poona.

The paper contains a discussion of the hourly measurements of the radiation from the night sky which were made simultaneously in February and March 1935 at the top of the tower of the Meteorological Office, Poona, at the Central Agricultural Meteorological Observatory at Poona or at the top of Sinhagad, a hill 2,500 ft. above Poona level and distant 15 miles from Poona. The measurements were made with Angstrom Pyrgeometers. At all the three places there was a decrease of radiation from the atmosphere after sunset, the decrease being most pronounced at the ground level and least so at Sinhagad level. The theoretical significance of these results is also discussed.

42. Derivation of a formula for nocturnal radiation and its relation to Angstrom's formula.

S. L. Malurkar, Agra.

The author has attempted to deduce a formula from the expression for the amount of radiation from a stratified atmosphere to approximate to the natural conditions. The formula deduced is

$$b\sigma\theta_0{}^4\{1-2Ei_3(aF+\alpha)\}$$

where a, b and α depend on the structure of the atmosphere, θ_0 is the surface temperature and F the total water-vapour content. The constants a, b and α depend on the structure of the atmosphere which cannot be assumed to be really same from day to day but which taken on an average would be approximately similar. Hence if individual measurements are made to fit the above formula the fit would not be good and may even be unsatisfactory, while if average values were taken the fit may be surprisingly good. This difference in fit with formulæ and actual measurements appears in all the empirical formulæ but no reason was assigned for the same. If the nature of the constants are properly appreciated, the difficulty disappears. As when x is large the value of $1-2Ei_3(x)$ is approximately equal to the value of $1-exp(-3x/_2)$ Angstrom's formula is a rough approximation to what theory would lead one to deduce.

Miscellaneous

43. Dielectric properties of some fatty acids.

G. R. PARANJPE *and* D. J. DAVAR, Bombay.

This is continuation of the work published in the *Proc. Ind. Acad. of Sc.*, Vol. 1, 1935, p. 880.

Dielectric properties of Oleic acid, Linolic acid and Triolene have been studied by using their solutions in Benzene. The Dielectric constants are determined at room temperature by observing resonance at 30 meters. An effort is made to interpret the results in the light of the Debye theory of polar molecules.

The absorption of radio-frequencies by some organic liquids is being studied with a view to obtain knowledge of the structure and size of molecules.

44. Dielectric dispersion and effect of temperature variation on the dielectric constant.

G. R. PARANJPE *and* P. Y. DESHPANDE, Bombay.

Higher fatty acids and their compounds are specially chosen to study the effect of high frequency variations on the dielectric constant. A study of the shift of the absorption band with temperature in the case of organic liquids is also undertaken.

Incidentally there is an attempt to inquire into the change of the capacity, which is often noticed, with the frequency of the radiator in resonance methods.

45. The ionisation obtained by bubbling air through solutions.

S. VENKATA RAMAN, Hyderabad (Deccan).

It is known that when air is bubbled through water and aqueous solution, electrical charges of both signs are carried along with it. In this paper, the relative amounts of positive and negative ions liberated when air is bubbled through aqueous solutions at different temperatures are recorded and it is shown that there is a marked change in the relative amount of positive to negative ions liberated at the transition point in the case of solution of certain salts with water of crystallisation.

46. On cathodic sputtering.

U. K. BOSE, Lucknow.

Part I. Quantitative measurements of Cathodic sputtering of silver in air was carried out by the method of finding (by weighing) the thickness of a deposited metallic layer on an interposed glass plate. The method of cathodic loss of weight was also used in some cases.

The results show that the sputtering is proportional to the time of exposure, and that in the case of pressure variation, a certain pressure is obtained for which the sputtering is maximum. Above this pressure the sputtering decreases exponentially, and below this pressure the sputtering decreases rapidly.

A rectangular glass plate interposed in the path of the sputtered particles showed that the sputtered particles bend round the upper plate, and the lower side of the plate receives a fairly thick deposit. The stand upon which the plate rests also gets a fairly thick deposit. This suggests strongly that the deposit forms a pseudogas. (This observation is quite in accordance with a somewhat similar observation made by A. London, 1900).

47. Ring phenomenon with cathodic sputtering.

U. K. Bose, Lucknow.

A new kind of ring phenomenon was noticed while working with the above apparatus. It is expected that this phenomenon will help us to form a mental picture of the mechanism of condensation of the sputtered particles. It was found that when a bead of plasticine or a drop of oleic acid was placed on a clean glass plate and then coated with cathodically sputtered silver or copper, brightly coloured rings are visible both in transmitted and in reflected light if the deposit of the metal be thin; and only in reflected light when the deposit was very thick. In monochromatic light the rings are alternately dark and bright.

It is suggested that the rings are interference rings due to the spreading of the oil on a metallic-vapour or liquid expanded film into which the cathodically sputtered silver or copper particles may be supposed to condense on the interposed glass plate. (The last mentioned assumption is supported by the experimental evidence obtained by Dictburn on the surface motion of cathodically sputtered cadmium on glass.)

48. A 24-inch reflector made in India.

H. Parameshwaran, Madras.

The paper describes the details of work in progress on a 24-inch reflecting telescope being made in India. The details of the grinding, polishing and figuring of the 24-inch mirror together with the details of the equatorial mount for it are discussed.

49. An 8′, 4 dial automatic electric tower-clock.

H. Parameshwaran, Madras.

The paper describes the design and construction of. a large tower-clock made in Madras for the Andhra University at Waltair.

50. On the intensity of multiple reflections at a grazing angle from a nearly parallel plate.

S. L. Malurkar *and* the late K. T. Kadaba, Agra.

Among the many images of the source of a distant light that are observed in a plate whose surfaces are inclined at a small angle—a portion of good plate-glass will do—and the plate is held near the eye so that the reflection is at a grazing angle, one image is the brightest and others successively less bright. By rotating the plate in its own plane it is possible to adjust that the topmost image is the brightest and the images begin to diminish in intensity downwards. If now, the plate is rotated in its own plane by 180°, the brightest image will be the bottom-most and the intensity begins to decrease upwards. A simple explanation is given and it is shown that the method is useful in the choice of a fairly good plate by mere inspection.

51. On the use of the apparatus for measurement of surface tension and density.

L. D. Mahajan, Patiala.

In the previous paper (*Jour. Sc. Instr.*, London, Vol. XIII, No. 6, p. 189), the author gave the construction, description and working of an apparatus for measurement of surface tension and density of the viscous as well as mobile liquids. In continuation of the same, it is found that

the results are most accurately obtained, if the following precautions are taken :—

1. The manometer must be of very uniform and narrow bore, say, 2 to 4 m.m. in diameter, so that the rise or fall of the liquid in the manometer be regular.
2. Mercury should not be used in the manometer, as being too heavy a liquid but a light and non-volatile liquid should be used, say, sulphuric acid or turpentine oil, for recording very small differences of pressure.
3. The Sutton's tube must be kept vertical, and in the same position for all observations.
4. The manometer levels should be recorded at least about five minutes after every disturbance of its liquid so that the disturbed liquid comes to stationary stage.
5. The Sutton's tube must be well cleaned and kept free from dust and grease, by boiling it for about two hours in a cleaning solution ($H_2SO_4+K_2Cr_2O_7$) and rinsing in specially prepared distilled water and dried.
6. The two radii of the Sutton's tube should differ as much as possible.

52. An optical method for the determination of the partial vapour pressures of liquid mixtures.

R. Sundararajan, Hyderabad (Deccan).

The method usually employed in determining the partial vapour pressures of liquid mixtures consists in chemically analysing a specimen of the mixture of vapours. In this method the Rayleigh Interferometer is used to determine separately the refractive indices of the vapours of the constituent liquids as well as the refractive index of the vapour mixture and hence the fraction of each constituent present in the mixture. The partial pressures are then calculated. The method has the advantage of being simple and also dispenses with the elaborate precautions found necessary in the chemical methods.

The partial vapour pressures of the following liquid mixtures were found—Ethyl alcohol and water, Benzene and Toluene, and water and n-propyl alcohol. The values obtained are in agreement with those given in the International Critical Tables. Further work is in progress and the method is being extended to determine the partial vapour pressures of mixtures of partially miscible liquids.

53. Oscillations of a column of liquid in a tube.

J. C. K. Rao, Hyderabad (Deccan).

A mathematical formula for the oscillations of a cylindrical column of liquid is developed and an expression found for the damping of the oscillation. The results agree generally with experimental results.

54. Measurement of viscosity by oscillating columns.

S. Venkata Raman, Hyderabad (Deccan).

A new method for the determination of the viscosity of liquids was described by the author in the Indian Journal of Physics, Vol. 8, p. 25–42, 1933. The method is applied to the determination of the viscosities of mercury and a few other liquids. The effect of amplitude of oscillation on the final results is also investigated.

55. The effect of static pressure on the oscillation of a string.

A. S. TAMBI RAJAH, Hyderabad (Deccan).

Vibration curves are obtained in the case of a bowed string with different pressures applied at any point of the string. A preliminary study of the curves shows that the higher harmonics are damped out even for small pressures. A more detailed analysis is being worked out.

56. On Nernst's proof of the unreachability of the absolute zero.

S. N. RAY, Lucknow.

Seven ' difficulties ' are pointed out in the proof of Nernst's principle, as reproduced by J. R. Cotter, in Preston's Theory of Heat (Fourth edition).

Radiation

57. Analysis of the spectrum of ionised Bromine.

K. R. RAO, Waltair.

In a previous report (*Ind. Sc. Cong.* 1936), it was stated that the structure of Bromine III was detected and that it was found to be in consonance with that of *As* I and *Se* II. A further comprehensive investigation carried out particularly to distinguish between the lines of *Br* II and *Br* III has led to a considerable extension of the scheme, which consists of doublets and quartets of the $4p$, $5p$, $5s$, $4d$ and $5d$ configurations. On account of very large intervals to be expected it is difficult to assign the L values to these terms. The reality of the levels themselves is unquestionable. About 200 lines of *Br* III have altogether been classified.

58. Extension of Tellurium III spectrum.

S. G. KRISHNAMURTY *and* K. R. RAO,. Waltair.

The present extension deals with the identification of the higher Rydberg members of the various terms reported previously (*Proc. Roy. Soc.*, A vol. 151, p. 178, 1935).

59. The spectrum of singly ionised Antimony.

S. G. KRISHNAMURTY, Waltair.

An investigation of the spectrum of singly-ionised Antimony in the region 6000– 2000 led to a modification and extension of the analysis of *Sb* II due to Land and Vestine. The $5s^25p\ 6p\ ^3D$ and $sp^3\ ^3P^o$ terms could now be identified with certainty and their harmony with the corresponding terms of homologous spectra definitely established.

60. The line absorption spectra of Nd^{+++} ions in crystals.

P. C. MUKHERJI, Calcutta.

The absorption spectra of Nd^{+++} ions in solution have been studied by the writer both qualitatively with spectrographs and quantitatively with a Hilsch double monochromator, over the whole spectral region from $950 m\mu$ in the infra-red to $210\ m\mu$ in the ultra-violet. It was found that some of the lines which appeared diffuse in solution, became sharper in crystal and to them many weak and fairly sharp components were added. With the lowering of temperature the spectrum was found to undergo remarkable changes. The diffuse lines became all very sharp, and some of them, rather broad, split up into finer components. At the temperature of

liquid oxygen many weak lines were highly intensified and some additional new lines appeared.

These sharp absorption lines in rare earth ions are due to transitions between the quantum levels in the $4f$ shell, which is screened from external disturbances by the ($5s$, p.) octet shell. With lowering of temperatures the thermal energy of lattice vibration is diminished. This makes the energy levels and hence the absorption lines still sharper. The intensification of some of the lines at low temperature is probably due to increased population of some of the lower levels. Over and above these general features, various other regularities have been observed among the absorption lines. The classification of the spectrum is in progress.

61. Hyperfine structure in Iridium.

B. Venkatesachar *and* L. Sibaiya, Bangalore.

Using a water-cooled hollow cathode and an aluminised Fabry-Perot etalon separated by invar distance pieces of different thicknesses, the structures of some arc lines of Iridium have been investigated. A previous study (Venkatesachar and Sibaiya: *Nature*, 1935, 136, p. 437; and *Proc. Ind. Acad. Sc.* 1935, 2, p. 203) had revealed the existence of two isotopes 191 and 193 with a relative abundance of nearly 1 : 2; this conclusion has been confirmed later by Dempster from a mass-spectrum of Iridium. The analysis of 3513·67 Å showed further that the nuclear spins of Ir 191 and Ir 193 are 1/2 and 3/2 respectively. The present investigation has led to the analysis of few more lines with the result that the previous conclusions have all been corroborated. The following table gives the experimental results:

Line.	Structure in Cm^{-1} (Wing.)					Remarks.
3513·67	+0·072 (7)	+0·032 (9)	0·000 (22)	−0·080 (13)	−0·151 (9)	
3800·10	+0·066	..	0·000	−0·053	−0·098	
2924·81	+0·060	..	0·000	−0·065	−0·118	
2849·74		+0·082(1)		0·000(2)		Isotope displacement.
2639·70		+0·083(1)		0·000(2)		Isotope displacement.

The above results lead to the further conclusion that the ratio of nuclear magnetic moments of Ir 191 and Ir 193 is nearly −0·92.

62. Nuclear spin of Rhodium.

L. Sibaiya, Bangalore.

Rhodium, according to Aston, consists of a single isotope of mass 103. A study of the hyperfine structure of some of its arc lines (for experimental details, vide: Venkatasachar and Sibaiya, *Proc. Ind. Acad. Sci.*, 1, p. 955, 1935) involving the ground state

$$4d^8 5s\ {}^4F_{4\frac{1}{2}},\ \text{viz.,}\ \lambda 3434{\cdot}90\ \text{Å}\ (4d^8\ 5s\ {}^4F_{4\frac{1}{2}} - 4d^8 5p\ {}^4G^{\circ}_{4\frac{1}{2}})$$

and $$\lambda 3692{\cdot}36\ \text{Å}\ (4d^8 5s\ {}^4F_{4\frac{1}{2}} - 4d^8 5p\ {}^4D^{\circ}_{3\frac{1}{2}}),$$

(Meggers and Laporte, *Phys. Rev.* 28, p. 654, 1926) shows that the nuclear spin of rhodium is $\frac{1}{2}\frac{h}{2\pi}$. Each line consists of a close doublet with

$$\Delta\nu = \sim 0{\cdot}060\ \mathrm{cm}^{-1},$$

whose relative intensities are in the ratio 11 : 9 as required by theory. The spin separation of $4d^8 5s\ {}^4F_{3\frac{1}{2}}$ could not be resolved. The magnetic moment of rhodium nucleus is therefore very small and positive.

White (*Introduction to Atomic Spectra,* 1934, p. 372) has given the nuclear spin of rhodium as $\frac{5}{2}\frac{h}{2\pi}$. This might have arisen from a possible confusion between rhenium and rhodium which exists in Gibbs' bibliography on line spectra of the elements (Gibbs, *Rev. of Modern Physics*, 4, p. 399, 1932.)

63. Band spectrum of diatomic Cadmium Iodide CdI.

T. S. Subbaraya, B. Nagesha Rao, *and* N. A. Narayana Rao, Bangalore.

The spectrum of the diatomic molecule CdI has been investigated by Wieland *Helvetica Physica Acta* 2, p. 46, 1929). He has analysed a system which appears in the near ultraviolet but not the system appearing in the red and yellow. Oeser (*Zs. f. Phys.* 95, 699, 1935) has investigated this system in fluorescence and absorption, but his measurements are too rough and the bands seem to have a spacing of more than 40 Å. By using a cadmium arc and two different types of water-cooled discharge tube energised by a 10000 volt ½ K.W. transformer we have been able to obtain bands with an E_1 glass-spectrograph and a 10ft. concave grating so as to obtain accurate wave-lengths. In every one of these cases an exposure of more than 20 to 30 min. was found to be impossible, because of the tubes cracking or the supply of cadmium iodide running out, hence the bands obtained were diffuse and very weak and could not be seen under the microscope with ordinary magnification. Accordingly the magnification of the microscope was reduced to about two diameters, and measurements were also made on a number of positives. In the case of the brighter bands the individual values do not differ from the mean by more than about 0·5 Å but there is greater deviation in the case of the weaker bands. A preliminary analysis shows that the red bands have the same upper level as those analysed by Wieland. The results of a final analysis based on wavelength data from a microphotogram of the plates will be published elsewhere.

64. The red band system of BeO molecule.

N. R. Tawde *and* V. S. Patankar, Bombay.

The authors have recently reported some new bands due to BeO in the photographic infra-red which they have tentatively attributed to ${}^1\Pi \rightarrow {}^1\Sigma$ system of the molecule. The original analysis of Herzberg showed the system to be deficient in these bands. Complete vibrational analysis of the band heads of this system along with the new bands is proceeding.

65. Simultaneous excitation of CN and AlO bands.

N. R. Tawde *and* S. A. Trivedi, Bombay.

The investigation has been undertaken with a view to ascertain whether the effective temperatures of the emission of two band systems in the same source can be the same. Distribution of intensity within the rotational levels has been shown by some previous authors to give

divergent results. Method of vibrational intensities has been adopted in this investigation. Data for calculating the temperatures has been obtained and the work is proceeding.

66. Influence of Argon on the emission of Swan bands.

N. R. TAWDE *and* D. D. DESAI, Bombay.

It is known that Swan bands can be excited in a discharge tube in the presence of argon. Discharge tubes provided with one aluminium and one carbon electrode and filled at various pressures (5 to 30 mm.) of argon have been prepared and the emission of Swan bands under these conditions has been studied by measuring their intensities. It is observed that the bands do not show all along the capillary portion of the discharge, but for a certain portion towards the carbon electrode. The exact role of argon is being investigated.

67. Ground state nuclear frequencies and distances.

N. R. TAWDE, Bombay.

The agreement of ground state vibrational frequency of molecules of the type M-N in the groups I and VII with the arithmetic mean of the frequencies of M-M and N-N has been shown to be closer for small difference in the masses of constituent atoms M and N. Also from the relation of ratio B_e/ω_e with reduced masses, it is possible to calculate the ground state nuclear distances of molecules in a group where they are not known from rotational structure. The calculation of restoring forces for group I and VII molecules shows certain irregularities in group I which are attributed to the break up of the harmonic law of force for such large nuclear distances (3 to 4 A.U.) as those in alkalis. Details are being published.

68. Study of oxy-coal-gas flame.

N. R. TAWDE *and* J. M. PATEL, Bombay.

By varying the coal-gas/oxygen ratio the intensity distribution of Swan bands emitted in the inner cone of the flame has been measured. The method of photographic spectral photometry has been adopted to determine quantitative values of the intensities of different band heads. Transition probabilities and temperatures on the basis of Boltzmann distribution have been calculated for different ratios. The relation between the ratio and temperature gives a curve having a maximum which in general does not coincide with the actual maximum attained in the flame.

69. Infra-red efficiency of some common light sources.

N. R. TAWDE *and* V. S. PATANKAR, Bombay.

In view of the recent progress made in the manufacture of the infra-red sensitive photographic material, it is desirable to gather information about the infra-red output of various sources of light. With this in view, by using a sensitive galvanometer in conjunction with a sensitive thermopile the following sources are being examined for infra-red energy : (i) Welsbach Mantle, (ii) carbon filament lamp, (iii) metal filament lamp, (iv) Nernst filament, (v) Globar heater, etc.

70. Infra-red contents of the solar radiations.

N. R. TAWDE, Y. G. NAIK, *and* R. H. NANAVUTTY, Bombay.

It is a well known fact that nearly all the near and the far infra-red part of the sun's spectrum is absorbed by the water of the atmosphere. From theoretical considerations, it is expected that the far infra-red beyond 400μ is again transmitted. Systematic observations are being made to study daily and hourly changes in the intensity of the light of the visible red, the near infra-red, the far infra-red and the far far infra-red of the sun. Study of the changes with altitude is also undertaken and it is expected that these measurements might be helpful in estimating the amount of water vapour in the atmosphere.

71. Ultraviolet content of the solar energy.

N. R. TAWDE, G. R. PARANJPE, *and* others, Bombay.

By using the methods of photographic photometry, the authors have recently reported results on the effective ultraviolet fraction in the solar energy at Bombay. These measurements are being extended further to collect data at different times of a day.

72. On the breadth of the Raman lines of water.

I. RAMAKRISHNA RAO, Waltair.

While all substances studied by the mechanism of the Raman effect are found to give rise to more or less sharp lines, water exhibits a very broad and diffuse band. This anomalous behaviour of water is explained on the basis of the high dipole-moment of its molecules.

73. Association in liquid mixtures.

C. SAMBASIVA RAO, Waltair.

That the effect of two associating liquids in solution with each other is to diminish the association of one another has been arrived at from the investigations of Jones and his co-workers. In his study of the constitution of water in solutions of acetone, formic and acetic acids by means of the Raman effect, the author obtained results which go to confirm the above observation—the association of the water molecules in solution with either of the above liquids decreasing with increasing proportion of the dissolved liquid.

74. Constitution of water in solutions of strong electrolytes. II

C. SAMBASIVA RAO, Waltair.

In continuation of the previous work of the author on this subject, some more substances belonging to the class of strong electrolytes, viz. $NaClO_4$, $NaClO_3$, $NaNC_2$, $HClO_4$, $CaCl_2$ and $CaBr_2$, have been investigated in their aqueous solutions with a view to study their influence on the constitution of the solvent, water, as evidenced by the changes in the structure of the Raman water-band in them compared with that in pure water. It is of interest to note that the behaviour of the calcium halides studied herein is analogous to that of HCl and LiCl studied before. The results obtained are interpreted on the basis of hydration and change in water equilibrium in the solution.

75. The infra-red and polarised light photography and photomicrography.

M. L. BHATIA *and* K. N. MATHUR, Lucknow.

The field of investigation opened by the developments in the infrared photography has been extended to a number of objects and living specimens. Comparative photographs have been taken with and without filters. Many interesting results have been obtained using a low power microscope. Photographs have also been obtained using polarised light from the 'polaroid' discs.

76. Investigations on the Raman spectra at low temperature: chlorobenzene, cyclohexane and phosphorus trichloride.

S. C. SIRKAR *and* J. GUPTA, Calcutta.

The Raman spectra of chlorobenzene, cyclohexane and phosphorous trichloride have been investigated in the solid state at the temperature of liquid air. Four new Raman lines lying in the neighbourhood of the Rayleigh line have been observed in the case of chlorobenzene and the positions of two of these lines are observed to be identical with those of two of such new lines observed in the case of *p*-dichlorobenzene at the low temperature. The intensities of some of these new lines are comparable to those of the intense Raman lines due to the single molecule. In the case of phosphorus trichloride and cyclohexane, however, no such new lines have been observed, though the Raman lines due to the single molecules have been recorded with moderate densities. In the case of both these substances, some of the lines due to the single molecules are observed to be split up, each into two components, and some of the lines are shifted towards the Rayleigh line with the lowering of temperature. These results will be discussed in a subsequent paper.

77. On the Raman spectra of different modifications of a few crystals.

S. C. SIRKAR *and* J. GUPTA, Calcutta.

Crystals of *p*-dichlorobenzene, *p*-dibromobenzene, sulphur and a few other substances have two modifications, there being a definite temperature in each case for the transformation from one modification to the other. Vuks (Comptes Rendus (Doklady) de l'Acad. des Sciences, Vol. 1, p. 79, 1936) observed that the positions of some of the new Raman lines which appear in the Raman spectrum of the crystals of *p*-dichlorobenzene in the neighbourhood of the Rayleigh line are different for the two modifications, and hence he concluded that these lines are due to lattice oscillations. In order to investigate this question more thoroughly, the Raman spectra of different modifications of crystals of *p*-dichlorobenzene and *p*-dibromobenzene have been investigated at different temperatures including that of liquid air. It has been observed that though the two substances are isomorphic, the changes observed in the case of *p*-dichlorobenzene mentioned above are not observed in the case of *p*-dibromobenzene. Furthermore, with the lowering of temperature of the crystals, other changes in the positions and properties of the lines are observed which cannot be explained by the theory of lattice oscillations. It is, therefore, concluded that these new Raman lines are not due to lattice oscillations but may be due to oscillations of polymerised groups.

78. Diffraction of electrons through thin films.

S. CHAUDHURI *and* B. B. RAY, Calcutta.

Experiments on the diffraction of electrons have been carried out using a very thin film of celluloid by transmission method. Voltages

varying from 15,000 to 30,000 volts have been used. The diffracted beam of electrons is allowed to act on a photographic plate placed normally to the beam at a short distance apart from the film. In all cases examined, three distinct rings appear on the plate, the rings being somewhat broad and diffuse. They indicate Bragg-spacings of 4·04 Å, 2·24 Å and 1·34 Å for the three rings respectively. In one plate, there is a very faint indication of a fourth ring when the electron beam is allowed to fall through a potential of 30,000 volts nearly.

79. On the theory of propagation of radio waves in upper atmosphere.

R. C. MAJUMDAR, Calcutta.

The Hartree-Appleton formula, which is so fundamental in all investigation of the upper atmosphere problem, is derived in the light of the new quantum mechanics. It is thereby revealed—which was hidden in the original classical treatment—that the Hartree-Appleton formula is to be modified by taking into account the quantisation of the motion of electrons in the earth's magnetic field.

80. On the structure of the allotropes of sulphur.

S. R. DAS, K. RAY, *and* B. B. RAY, Calcutta.

A structural analysis of the following allotropes of sulphur has been carried out applying the Hull-method: (1) roll sulphur, (2) flower of sulphur, (3) milk of sulphur, (4) white sulphur, (5) colloidal (gel) sulphur and (6) plastic sulphur. The present authors have observed that under similar experimental conditions, the diffraction patterns of (1)—(5) bear a strong point-to-point resemblance to one another. In each four rings corresponding to the Bragg-spacings: 3·89Å, 3·18Å, 2·45Å and 2·15Å were obtained. From this it has been suggested that all of them represent one and the same allotrope of sulphur and all belong to the orthorhombic class of crystals (V_h^{24}). Plastic sulphur appears to be really amorphous exhibiting only one ring which indicates a spacing of 3·52Å. No definite conclusion has been reached, as yet, regarding the colloidal (sol) sulphur.

81. Crystal structure of para-dihalogen derivatives of diphenyl.

J. DHAR, Calcutta.

The crystal structures of the three para-dihalogen derivatives of diphenyl, namely 4-4′ difluorodiphenyl, 4-4′ dichlorodiphenyl and 4-4′ dibromodiphenyl have been studied by X-ray methods. The crystals are monoclinic and are isomorphous; their unit cells are found to have the following dimensions:—

Crystal.	'a'	'b'	'c'	B (goniometric).	Number of molecules per unit cell.
4-4′ difluorodiphenyl.	14·83Å	13·30Å	9·45Å	96°8′	8
4-4′ dichlorodiphenyl.	15·94Å	13·61Å	9·79Å	96°48′	8
4-4′ dibromodiphenyl.	15·8Å	14·09Å	9·82Å	94°30′	8

From the cell dimensions given in the table it appears that the molecules have very probably an extended structure like diphenyl, and are oriented in the crystal with their lengths nearly along the 'b' axis, the molecular planes being thus nearly perpendicular to (010). This result is in conformity with the magnetic data for the crystals given by Krishnan and Banerjee; the susceptibility of the crystal is numerically a minimum along the normal to (010), and its value is equal to that of the molecule along directions lying in its plane.

82. Two crystalline modifications of naphthacene.

J. Dhar, Calcutta.

From a solution of naphthacene in chloroform two different types of naphthacene crystal were obtained; one needle-shaped and the other flaky. Rotation and Weissenberg photographs about the elongated axis of the first type show that the crystal belongs to the tetragonal class with the following dimensions for the unit cell :—

$$a = 12{\cdot}07\ \text{Å}$$
$$c = 3{\cdot}95\ \text{Å}$$

The flaky type of crystal also has been studied by the usual X-ray methods with fixed and moving-film cameras. It is found to belong to the monoclinic class with the following elements :—

$$a = 7{\cdot}6\ \text{Å}$$
$$b = 6{\cdot}05\ \text{Å} \qquad \text{and } \beta = 105°$$
$$c = 13{\cdot}05\ \text{Å}$$

Both the crystals have nearly the same density, *viz.* 1·405 from which the number of molecules comes out as 2 per unit cell for both the crystals.

83. Atomic arrangement in benzamide crystals.

K. Banerjee *and* N. M. Saha, Dacca.

Benzamide crystals show dimorphism. Both the varieties are monoclinic prismatic. Goniometric and complete X-Ray study of one of the modifications has been made. The following values of the cell dimensions have been found.

$$a_0 = 21{\cdot}98\ \text{Å}$$
$$b_0 = 5{\cdot}503\text{Å} \qquad \beta = 90°22$$
$$c_0 = 5{\cdot}021\text{Å}$$

From oscillation photographs about two of the crystallographic axes the space-group has been found to be $C^1{}_{2h}$ $P2/m$ with four molecules per unit cell. Intensities of reflections were measured from powder photographs by a Zeiss Photometer. By the trial and error method it was found that the molecules lie very nearly along the *b*-face with two molecules along the *b*-axis and two molecules lie lengthwise along the *a*-axis.

84. Arrangements of the benzene rings in benzophenone.

K. Banerjee *and* Abdul Haque, Dacca.

In benzophenone two benzene rings are linked by a single CO group, so if the inclinations between tetrahedral bonds be preserved the two benzene rings should be inclined to each other in contradistinction with diphenyl, dibenzyl and benzil. For testing this, the space-group of benzophenone was determined by a set of oscillation photographs about the c-axis and a Weissenberg camera photograph of the equatorial layer line about the *b*-axis. The space-group is D^4_2 $P2_12_12_1$ and there are 4

molecules per unit cell. There is no molecular symmetry. From the molecular dimensions and the obeserved diamagnetic susceptibilities the following is the only possible arrangement:

The two benzene rings of the benzophenone molecule are inclined to each other at 135° nearly, the connecting *c*-atom lying at the intersection of these two planes; the line bisecting the acute angle between these planes lies along the *b*-axis and the mean plane is inclined to the *c*-axis by 22°.

85. Arrangements of the benzene rings in hydrazobenzene.

K. BANERJEE *and* N. M. SAHA, Dacca.

The spacegroup of hydrazobenzene was found to be D^{5}_{2h} Pmcm from oscillation photographs about *a* and *b* axes. The number of molecules per unit cell is 4. So each molecule may have either of the following symmetries: (1) axis of symmetry along *a*-axis, or (2) plane of symmetry parallel to *a*-face, (3) plane of symmetry parallel to *c*-face. Out of these alternatives: (1) and (2) are impossible in view of the size of the molecule and also the diamagnetic susceptibilities of the crystal along the three axes. On trying to fit in the molecular symmetry in the unit cell, so as to obtain the observed susceptibilities, the following orientations were found: the two benzene rings are equally inclined on the same side of the N-N line by 16°, the N-N line being along the *c*-axis; the mean molecular plane is inclined to the *a*-face by an angle of 49°.

86. Crystalline structure of organic saturated ring compounds.

K. BANERJEE *and* ABDUL HAQUE, Dacca.

The molecules of biological products are in general too complex for complete analysis. But the most important building stones of such compounds are reduced rings hydroaromatic as well as heterocyclic. It is expected that if we have correct knowledge of the structures of simple compounds containing such rings, the more complex molecules of the biological products should come within control. Attempts have been made to study the structures of Decahydro-β-naphthol and creatinine. Creatinine has the following cell dimensions:

$$a_0 = 14{\cdot}86\text{Å},\ b_0 = 13{\cdot}14\text{Å and } c_0 = 5{\cdot}85\text{Å and } \beta = 110°36.$$

There are 8 molecules per unit cell and the space-group is $C^1{}_{2h}\ P2/m$ and so two molecules form an asymmetric unit. Decahydro-β-naphthol has the following cell dimensions:

$$a_0 = 8{\cdot}489,\ b_0 = 6{\cdot}856 \text{ and } c_0 = 17{\cdot}16\text{Å and } \beta\text{-} = 109°22.$$

There are four molecules in the unit cell.

Complete study will be the subject of a future communication.

87. Space-group of $IrCl_3$, $3(C_2H_5)_2S$.

K. BANERJEE *and* ABDUL HAQUE, Dacca.

The substance was crystallized from benzene and from a combination of goniometric measurements and Laue photographs, the cell dimensions axial angles and the space-group were determined. The following values were obtained.

$$a_0 = 9{\cdot}066\text{Å};\quad b_0 = 11{\cdot}83\text{Å};\quad c_0 = 10{\cdot}64\text{Å}\quad \alpha = 98°46;\quad \beta = 92°34\quad \gamma = 96°54$$

Space-group is $C_1 P\ 1$

The number of molecules per unit cell is 2 and therefore two molecules form one asymmetric unit.

Statistics

88. The use of intrinsic rectangular co-ordinates in the theory of distribution.

P. C. Mahalanobis, R. C. Bose, *and* S. N. Roy, Calcutta.

We consider a normal p-variate population. A sample of n from this population can be represented after R. A. Fisher by a single point in a space of np dimensions. The p characters are then represented by the projections of the sample point on the p sub-spaces each of n dimensions. If the p sub-spaces are so rotated as to fall on the same sub-space of n dimensions, and each character point is then translated parallel to the equiangular line, so that the foot of the perpendicular from it to the equiangular line coincides with the origin; the character points come to lie in a flat space of n-1 dimensions orthogonal to the equiangular line. The figure now formed by the p-character points, depends upon $p(p+1)/2$ parameters. These parameters we define as the measures of the links of a number of rectangular chains and we call them the intrinsic rectangular co-ordinates of the sample. If $t_{ij} (i \leq j.\ j=1,\ 2,\ \ldots\ p)$ are the intrinsic rectangular co-ordinates, we obtain this joint distribution in a form which easily yields a large number of known distributions as well as a few hitherto unknown distributions.

89. The normal frequency distribution.

R. Vaidyanathaswami, Madras.

It is shown that the concept of the normal distribution belongs to affine vector-theory in a space with a Euclidean metric and that the distribution carries with it an associated metric. The concept of correlation is shown to have its origin in the associated metric.

90. Rationale of the method of least squares.

R. Vaidyanathaswami, Madras.

The method of least squares is better called the method of least distances. In substance it is an affine vector-theory in an Euclidean metrical space. The geometrical view-point leads at once to the notion of the weight to be attached to linear equations.

91. On a method of testing the association between thunderstorm and upper air ionisation.

S. S. Bose *and* P. C. Mahalanobis, Calcutta.

Dr. S. K. Mitra and his associates in the Science College, Calcutta, undertook a series of observations on the state of upper air ionisation at five or six hours of the day during April to July in 1935. Some of these observations coincided with the occurrence of thunderstorms or magnetic disturbance and the problem was to test how far an abnormality in the upper air ionisation was associated with the simultaneous occurrence of a thunderstorm or magnetic disturbance. This is an example of two variables which are classified in categories and not in quantitative measures. Pearson's method of contingency can be used for analysis and the results show that (i) a significant positive association ($+0{\cdot}50$) exists between the occurrence of a thunderstorm and an abnormal activity in the upper air, and (ii) the association, if any, between magnetic disturbance and abnormal ionisation is not appreciable.

92. The relative efficiencies of estimates of regression coefficients by the method of differences.

S. S. Bose, Calcutta.

The regression coefficient of one variable y on x is defined as $b = s(x-\bar{x})(y-\bar{y})/s(x-\bar{x})^2$ and the standard error of $b = \sqrt{[s^2/s(x-\bar{x})^2]}$ where s^2 is the variance of b. But although this estimate of regression coefficient is the most efficient in the Fisherian sense, other estimates are sometimes preferred on account of simplicity of calculation. Three methods of estimating b have been suggested : (*i*) the method of successive differences, (*ii*) the method of differences at half range and (*iii*) the method of range. The standard errors and efficiencies of these estimates as compared to the least square solution have been calculated, and it has been shown that while the efficiencies of first and third methods rapidly fall as the size of the sample increases, the efficiency of the second method of estimates is always above 75 per cent. which value it attains when n tends to infinity.

93. On the analysis of k samples from Poisson population.

P. V. Sukhatme, Calcutta.

A statistical technique called the technique of 'Count' analysis for samples drawn at random from a Poisson population has been developed. In particular three statistical hypotheses corresponding to Neyman and Pearson's H_1, H_2 and H hypotheses for the Normal Law Variation are considered and the principle of likelihood ratio is applied to get suitable criteria based on observations. It is shown that the criteria follow the well-known Pearsonian χ^2-distribution with degrees of freedom appropriate to respective hypotheses. It is emphasised that the tests are approximate and that the approximation becomes satisfactory when m the population parameter is as large or larger than 3. A similar set of hypotheses with their criteria are given for samples of the Binomial population.

94. Tests of significance for samples of the χ^2 population with two Degrees of Freedom.

P. V. Sukhatme, Calcutta.

A statistical technique called the technique of 'interval' analysis is developed for samples drawn at random from the Exponential population. It is shown that the tests of 'interval' analysis are perfectly analogous to those of Analysis of Variance tests for the Normal Law Variation. It is emphasised that the published tables of χ^2, t and z can be used to obtain the five and one per cent. levels of significance for the corresponding tests of the exponential theory with appropriate modifications in respect of degrees of freedom.

95. A note on a theorem due to Hermite.

N. M. Basu, Dacca.

One of the theorems proved by Hermite in a memoir published in Crelle's Journal for 1854 is the following :—

The number of solutions, modulo p, of the congruence

$$x^2 + ay^2 \equiv b, \text{ mod } p,$$

where p is a prime and b is not divisible by p, is $p - \left(\frac{-a}{p}\right)$.

The object of this note is to point out that the above theorem can be proved in a simple and elementary manner with the help of the following result due to Jacobsthal:—

$$\sum_{k=1}^{p} \left(\frac{k^2-a}{p}\right) = p-1-p\left(\frac{a}{p}\right)^2.$$

N.B.—The bracket expressions are the usual Legendre symbols.

96. On the determination of the velocity of sound in air completely saturated with water vapour at various temperatures.

H. G. Mohamed, Allahabad.

In the present paper which is a continuation of the previous work already published, the author has given more accurate results of his experiments on the velocity of sound in air completely saturated with water vapour at various temperatures ranging from about 15°C. to 95°C. by using a more refined apparatus and giving due consideration to some of the factors which could not be well controlled on the previous occasion. In these determinations the resonating tube method was adopted. This was done by setting up stationary waves in the tube by means of a telephone diaphragm, actuated by a source of constant frequency, namely, a valve maintained Elinvar steel tuning fork oscillator and measuring the internodal distances $\lambda/2$. The tube-velocity of sound in saturated air at any particular temperature was then obtained as a product of the wavelength, λ, and the frequency, N. (997·5 cycles per sec.) of the source. To this value of the tube velocity, an accurately determined tube correction was added to get the free space velocity of sound.

From these determinations, the values of Γ the specific heats ratio, for saturated air at various temperatures were obtained by using the basic formula

$$V = \sqrt{\frac{P.\Gamma}{\rho}}$$

where P is the total pressure inside the resonating tube and ρ is the density of the saturated air. In obtaining the values of ρ, the experimental values of the density of moisture contained in the saturated air were taken from a paper by J. H. Awbery (Proc. Phys. Soc., Vol. 44, 143, 1932).

The discrepancies in the previous results have been shown and discussed.

97. The effect of the spacing of a partition from a reflecting surface on its sound absorption coefficient.

H. G. Mohamed, Allahabad.

The present paper is a study of the variation of the sound absorption coefficient, α, for a cloth partition placed at several distances from the reflecting surface. The materials so far used, in preparing the specimen partitions to be tested, were ordinary coarse canvas and the ordinary red cloth.

The method adopted in the investigation of this problem was the well-known stationary wave method previously used by E. T. Paris and others. The source of sound employed to set up stationary waves in the experimental clay pipe was a moving coil type loud speaker which was fed by a valve maintained tuning fork oscillator (frequency 512 cycles per second) used in conjunction with a single-stage valve amplifier. The output and the frequency of the source of sound could be kept very

constant and any changes in the intensity of sound could be minutely detected by means of a sensitive galvanometer which was fed by direct current from a copper oxide metal rectifier placed in series with the primary of the loud speaker. The 'battery type' of bridge, along with a compensating hot-wire microphone was used in finding out the resistance changes. The detecting instrument was a hot-wire microphone with a moving coil mirror galvanometer. The apparatus with these refinements was found to be capable of giving very accurate results.

The work is still in progress and this paper may be taken as a preliminary report.

98. A new method for the investigation of the rotation of the earth.

B. DASANNACHARYA *and* DINKAR HEJMADI, Benares.

By studying the small ellipticities developed in the orbit of the bob of a Foucault pendulum it has been possible to connect the experimentally determined ellipticities with angular velocity of the rotation of the earth.

99. A Seismograph for heavy earthquakes.

M. U. UPPAL, Lahore.

The writer has set up a Seismograph in the Physics Laboratory of the Government College, Lahore, in which the change of gravitational force on a mass appears as a change of pressure of air enclosed in a chamber. In practice the instrument consists of an air-tight chamber provided with an inelastic membrane at the bottom. A weight is attached to the membrane and the chamber partially exhausted so that the whole weight is supported by air. The changes in pressure are communicated to a specially constructed manometer and are recorded automatically. The relation between the movements of the earth and curve displacements has been established. The instrument measures the vertical component of the force and is designed to stand great upheavals. It has been worked for ground displacements up to 30 cms.

100. Excitation of Counts in Geiger Point Counters.

B. DASANNACHARYA *and* T. S. KRISHNAMOORTI, Benares.

The study of counts in the region of voltage between the saturation value and the threshold values has been made spatially symmetrical with the axis. It is found that the counts registered show a minimum along the axis. They rise to a maximum at a definite inclination symmetrically about the axis and diminish again for greater inclinations. As the voltage reaches the saturation value the anomaly gradually disappears and the counts registered are maximum along the axis itself. Important conclusions can be drawn from these as regards the mode of excitation of the counts.

101. Influence of metals in the sensitiveness of Geiger Mullar Line Counters.

B. DASANNACHARYA *and* G. S. RAO, Benares.

It is found that the γ rays act photoelectrically on the metal of the outer plate electrode and releases β particles which can inhibit the registration of counts. The effect shows itself in the variation of sensitivity of the counter along the axis of the tube. It rises to a maximum flush with the end, then falls to a minimum, rises to a maximum of smaller intensity and falls again asymptotically as we recede further away from the ends, outward.

SECTION OF CHEMISTRY

President :—PROF. J. N. RAY, PH.D., D.Sc., F.I.C., F.N.I.

Presidential Address

THE CHEMISTRY OF ANTIMALARIALS

While I greatly appreciate the honour of being called upon to preside to-day, I am also conscious of my limitations. The success of the present session will therefore depend largely upon your kind co-operation which, I am sure, you will ungrudgingly give. It is this consideration that has emboldened me to accept the responsibility of presiding over the deliberations of the Chemistry Section of the Indian Science Congress of 1937.

Malaria is the greatest obstacle to the progress of India. Apart from the terrible toll it takes annually in the form of human life, its influence on labour inefficiency is a serious factor in the industrial development of the country. The physical, intellectual and economic deterioration of this sub-continent can be attributed mainly to this one cause. For this reason no subject can be of greater interest to us than an account of the recent developments in the prevention and cure of Malaria by chemicals.

Originally Chemistry was the handmaid of Medicine but the subject acquired an independent status in the early 19th century. From that time until recently the development of chemistry proceeded entirely on structural lines. The amazing growth of the dyestuff industry was possible because the study of the relation between chemical constitution and colour is comparatively a simple problem, only one physical property, the absorption of light being involved. The slow growth of the science of chemotherapy is due to the fact that physiological action has no simple meaning, but covers every action a chemical may exert on the living organism. Complexity is increased because the same action may be brought about by a multiplicity of causes having no relationship with one another. For example, purgation is caused by saline cathartics like magnesium sulphate and also by anthraquinone derivatives. In the first case the action is due to the increase of fluid in the intestines due to osmosis whilst in the latter case the drug irritates the epithelium of the intestines causing increased peristalsis, and a generalization based on the similarity of the physiological action of the two drugs would lead to highly misleading results.

The investigation of the nature and properties of a drug begins with the isolation of the active principle to which its

physiological action is due. This is followed by a determination of its structure by analytical and synthetic means and after its molecular arrangement has been unravelled, a study of the related derivatives makes it possible to locate the seat of pharmacological action. As an illustration the case of quinine affords a most striking example. Cinchona bark was used as a febrifuge in the 15th century. Chemical investigation in the 19th and the present century has settled the structure of quinine and its allies.

An examination of the structure of quinine reveals three distinct centres to which its physiological action may be attributed :—

(1) The quinoline ring with the methoxy group.
(2) The quinoclidine ring.
(3) The vinyl grouping. We have also to consider the alcoholic (secondary) grouping.

That cinchonine is less effective against malaria than quinine (Giemsa, *Arch. Schiff's Tropen. Hyg.*, 1914, *18*, 12) was confirmed a few years later by Meldolesi (*Cuore Circulat.* 1925, *9*, 353), who is also of opinion that it is more toxic to the heart than quinine. In contrast to quinine, cinchonine does not prevent the emigration of leucocytes (Ikeda, *J. Pharmacol.*, 1916, *8*, 101). This is in harmony with the observation of Shaw (*Am. J. Hyg.*, 1928, *8*, 583) that the absence of methoxy group lowers the partition coefficient of the alkaloids of the quinine group. So far as the action on uterus is concerned cinchonine is more effective than quinine. All these differences in action are due to the influence of the methoxy group on the physical properties of the molecule. The solubility in fats and lipoids, the surface tension and other physical properties are influenced by the entry of the methoxy group. As regards the antimalarial action, it has been assumed by Morgenroth (*Deutsch. med. Wochenschr.*, 1918, *44*, 729) that quinine is concentrated on the surface of red blood cells rendering these impermeable to parasites but Giemsa (*Munch. Med. Wochenschr.*, 1928, *11*, 731) casts doubt upon this assumption. Shaw and Manwell (*Am. J. Hyg.*, 1928, *8*, 583) are of opinion that only those quinine derivatives are antimalarials which are soluble in red blood cells. Therefore, the difference of antimalarial properties of quinine and cinchonine may be ascribed to the increase of solubility of the former alkaloid in red blood cells, caused by the presence of the methoxy group. Kehar (*Ind. J. Med. Res.*, 1931, *18*, 203, 987, 1001) has studied the penetration of quinine and other alkaloids into gels. A study of the effects of various groups in enhancing the permeability of quinine would be valuable, as a quinine derivative of increased permeability would be an antimalarial of increased activity.

The position as regards cinchonine and quinine can be

summed up as follows: Antimalarial action is present in cinchonine but is less marked than quinine. The effect on the cardiac muscle is about the same. Cinchonine does not affect the dispersal of the leucocytes so much as quinine does. The latter difference runs parallel to surface tension and a comparative measurement of this property is being undertaken which will probably furnish an explanation.

When the antiseptic properties of 2-methyl-4-phenyl quinoline and 6-methoxy-2-methyl-4-phenyl quinoline to paramoecia are compared, it is found that the methoxy compound is more toxic. Similarly, 6-methoxy-4-methyl quinoline is more toxic than 4-methyl quinoline. Thus, there is no doubt that the presence of the methoxy group is helpful so far as the antiplasmodial action is concerned. One naturally enquires what effect there would be if the methoxy group were replaced by its higher homologues. It has been found that an improvement occurs with ethoxy cinchonine but further lengthening of the ether chain decreases antimalarial action.

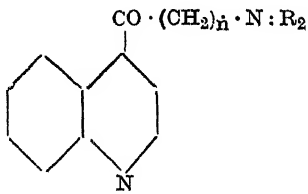
The Vinyl Grouping.—Hydrogenation of the vinyl grouping increases antimalarial action, e.g. hydroquinine is more efficient than quinine and hydrocupreine than cupreine, but mere hydrogenation does not produce antimalarial activity where none is present in the original unsaturated compound. The addition of hydrogen chloride or the elements of ammonia or water to the double bond does not affect antimalarial properties. From these facts it seems certain that the vinyl group is not directly concerned with the antimalarial action of quinine, though the destruction of the vinyl grouping and its replacement by a carboxylic group results in the total extinction of antimalarial action. This loss of activity by the introduction of a carboxylic acid is more or less a general phenomenon. The lactone, pilocarpine becomes inactive on the addition of alkali, while a series of tropeins containing a lactone grouping similarly lose their atropine-like action on the addition of a molecule of alkali. Just as benzoylecgonine carboxylic acid has no local anæsthetic action but develops it on esterification, so the quinine derivative in which the vinyl group has been replaced by a carboxyl group acquires antimalarial properties on esterification.

Stereoisomerism around the secondary alcoholic group has no material influence on the antimalarial properties of quinine (cf. quinine and quinidine) but the replacement of the hydroxyl group by hydrogen, chlorine or acetoxy groups results in the total loss of antimalarial property.

Before proceeding further it will be helpful first to consider the site of antimalarial activity. Shaw (*loc. cit.*) is of opinion that the comparatively low toxicity of quinine in *vitro* suggests that the site of the action is in the red blood corpuscles. Hence, in order that a drug may be an antimalarial, the first requisite is that in addition to possessing antiplasmodial properties, it

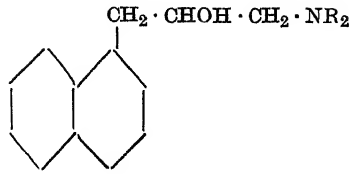
must be able to penetrate the erythrocytes. Therefore, any change in structure which reduces permeability reduces antimalarial action. The removal of the methoxy group reduces partition coefficient hence cinchonine is inferior to quinine. The hydrogenation of the vinyl group results in no material change in the partition coefficient, hence no profound changes are observable after hydrogenation although some improvement is noticed. The replacement of the vinyl by a carboxyl group produces a complete loss of the penetrative power resulting in the destruction of antimalarial properties. The experiments of Kehar (*loc. cit.*) concerning the ability of cinchona alkaloids to penetrate gelatin gels would acquire more significance if the anion is kept constant in the case of every alkaloid. The penetrability of quinine hydrochloride would not be comparable with that of a different salt of cinchonine.

It has been mentioned that the stereo-chemical configuration of the secondary alcoholic grouping has no direct bearing on the antimalarial action but modification of this part of the molecule results in loss of activity (cf. Hildebrandt, *Arch. expt. path. Pharmakol.*, 1908, *59*, 127). Oxidation of the alcoholic group to the corresponding ketone (cinchonone or quininone) does not materially diminish the pharmacological properties. After the administration of cinchonone, cinchonine can be isolated from the urine indicating reduction in the organism. On the other hand, Ruzicka, Seidel and Liebel (*Helv. Chim. Acta*, 1924, *7*, 995) have prepared a series of quinotoxine-like compounds of the following general formula (I) :—



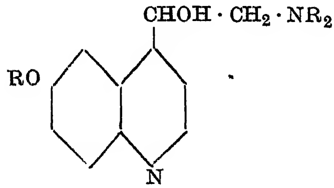
(I)

But these had no curative value in malaria. From these results it would appear that antimalarial properties cease with the oxidation of the secondary alcoholic grouping, while the activity of cinchonone and quininone is due to their partial reduction to the corresponding alcohols in the system. It appears probable that the antimalarial properties of these drugs are closely connected with the existence of the secondary alcoholic grouping between the quinoline and quinuclidine part. Fourneau *et al* (*Ann. Inst. Pasteur*, 1931, *46*, 514) prepared a number of secondary amino alcohols belonging to the naphthalene series (II) which, in some cases, showed some effect in bird malaria but were non-effective in the case of man :—



(II)

On the other hand, a number of compounds with the following general formula (III) have been found to be powerful febrifuges with low toxicity to man (Pyman, *J.*, 1917, 1103) :—



(III)

This difference in behaviour of two structurally related types can be explained when it is recalled that quinoline has pronounced antiseptic properties, so much so that animals poisoned with quinoline do not putrefy for a considerable time. Quinoline itself has been reported to have antiseptic properties also.

Hydrocupreine Derivatives.

It has been stated that the reduction of the vinyl group does not affect antimalarial property. Optoquine (ethyl hydrocupreine, IV, R=Et) has strong antiseptic property and inhibits fermentative reactions in the same manner as quinine.

RO——Quinoline half——CH · OH——Meroquinine
|
$CH_2 \cdot CH_3$

(IV)

Morgenroth and Levy (*Berl. klin. Wochschr.*, 1911, *48*, 1560, 1979) found it to be prophylactic against pneumococci infection. The *iso*propyl analogue is half as effective whilst the *iso*amyl compound (IV, $R=C_5H_{11}$) (Eucupine) is one-twentieth as active as quinine but optoquine is 150 times more effective against pneumococci. Eucupine (*iso*amyl dihydro cupreine) has pronounced local anæsthetic action, being twenty times more active than cocaine (Dixon and De, *J. Pharmacol.*, 1927, *31*, 407), but its antipyretic action is negligible in pyrexia induced by *B. Coli Communis* broth.

Vuzin (*iso*octyl hydrocupreine) has been used as an antiseptic in gas gangrene. Its antipyretic action is more marked than eucupine.

Ghosh and Chatterji (*J. Ind. Chem. Soc.*, 1931, *8*, 257) have described *iso*propyl, secondary octyl hydrocupreidine. Later on (*ibid.*, 1932, *9*, 83) they also prepared some *n*-alkyl hydrocupreidines. The properties of these compounds have not been described but, in view of the fact that the stereochemical configuration of the secondary alcoholic group does not modify the pharmacological properties to any great extent, one would not expect any great variations in physiological action from the corresponding hydrocupreins. MacGilchrist (*Ind. J. Med. Res.*, 1914-15, *2*, 315; *ibid.*, 1915-16, *3*, 1) on a clinical comparison found quinine sulphate to be of the same order of value as quinidine sulphate, the two substances differing in the sign of the carbon atom bearing the alcoholic hydroxyl group. The question of the difference in physiological action of stereoisomerides is a baffling one. *d*-Histidine tastes sweet, whilst *l*-histidine is tasteless. So far as the action on nerve endings is concerned Cushny (*Lancet*, Sept. 16th, 1916, p. 459) has pointed out that *l*-hyoscyamine has about 100 times the mydriatic action of the *d*-variety. The difference in activity of *d*- and *l*-adrenaline is also well-known, while pilocarpine and *iso*-pilocarpine also form another pair in which a large difference in activity is noticed. The difference of action of the stereoisomerides may lie in their respective abilities to combine with the constituents of the nerve cells, but even in the action on nerve endings, *d*- and *l*-homoatropine differ little from one another in mydriatic action.

It seems obvious that, although in *vitro* some differences may be noticed in their toxicity to paramoecia, clinically, the isomerides of the quinine series show little difference in action (cf. MacGilchrist, *loc. cit.*).

From the foregoing summary it would appear that the seat of antimalarial action of quinine is in the quinoline nucleus and that it is augmented by the presence of a secondary alcoholic group. It has already been stated that γ-substituted quinolines having a secondary alcoholic group in the side chain possess antimalarial property. This has stimulated the synthesis of quinoline derivatives with appropriate substituents in recent years.

Quinoline Derivatives.

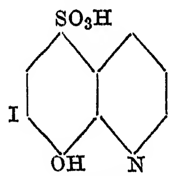
From a study of a large number of alkyl quinolines, it has been found that the presence of a methyl group in the quinoline ring reduces the toxicity for the central nervous system but increases it for the heart. The position of the methyl group has little influence on the toxicity.

Of the hydroxyquinolines (V, VI and VII), the 3-hydroxy compound (VI) seems to be clinically successful in the treatment of gonorrhoeal urethritis of the anterior type (Davin and Schlauch, *Am. Med.*, 1932, *38*, 9).

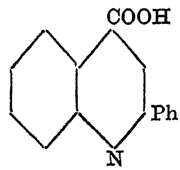
α -Hydroxyquinoline (V) β -Hydroxyquinoline (VI)

γ -Hydroxyquinoline (VII)

Of the quinolines with a hydroxy substituent in the benzene ring, the sulphate of the 8-hydroxy compound is known as 'quinosol', the antiseptic properties of which have been found to favour the healing of inflammatory processes. The position of the hydroxy group, unlike that of the methyl, is important in modifying the physiological action, e.g. 2-hydroxyquinoline (V) is distinctly toxic but differs from the 8-hydroxy compound in exerting a depressant action on the central nervous system. A number of derivatives of 8-hydroxyquinoline have been prepared, of which 7-iodo-8-hydroxyquinoline 5-sulphonic acid is the important compound 'yatren' (VIII) which has been extensively used as an antiseptic in the treatment of open wounds.



(VIII)



(IX)

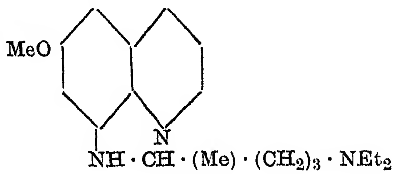
It has been claimed that the oral administration of yatren stimulates the self defence mechanism.

Another important simple quinoline derivative is the substance IX, known as 'cinchophen'. It has antipyretic properties and also antiphlogistic action, but its most important property seems to be the stimulation of the secretion of uric acid process. The uric acid content of blood reaches a low level after its administration but returns to normal soon after the administration of the drug is discontinued. Several fatal accidents have been reported after the use of cinchophen mainly due to the severe pathological changes it induces in the liver. Several substances related to cinchophen have been synthesized but no definite relationship between their efficiency as uric acid removers or their chemical structure has been established. Ogden and Adams (*J. Am. Chem. Soc.*, 1925, *47*, 826) have prepared the 4′-arsonic acid of cinchophen but this compound

was found to be less trypanocidal than arsphenamine and it had no antimalarial property.

Plasmoquine.

Schuleman, Schoenhoefer and Wingler (D.P.R., 541730, 1925) synthesized several quinoline derivatives with an alkyl amino side chain, the most successful has the structure (X) and was designated as plasmoquin.



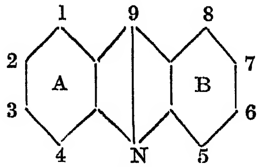
(X)

This compound is not bitter and has definite antimalarial action. Plasmoquin is distinctly less toxic to paramoecia than quinine. Rohl (*Arch. f. Schiff's Tropen-hyg.*, 1926, *30*, 3, 11) studied its antimalarial action in bird malaria and reported that it inhibits the development of the plasmodia, though according to Hegner and Manwell (*Am. J. Trop. Med.*, 1927, *7*, 279) it does not destroy all the parasites in blood. The schizontes were not affected to the same extent as with quinine but there is a definite gametocidal action. Since gametes are responsible for the transmission of the disease, hence plasmoquine can be regarded as a preventive of malaria but not an actual antimalarial when used alone (Pillsbury, *J. Am. Med. Assoc.*, 1930, *95*, 991). But according to Napier, Butcher and Das Gupta (*Ind. Med. Gaz.*, 1932, *47*, 186) plasmoquine administered three times weekly caused a much higher incidence of malaria amongst protected population. On the other hand, several workers lately have reported its value in checking the spread of malaria. It is not claimed that plasmoquine is a substitute for quinine but that it can be used with quinine owing to its more toxic action on gametocytes. The quinine-plasmoquine treatment has been tried on a large scale by the Bengal Government and from the statement issued by the Director of Public Health, it would appear that the selected population has definitely benefited by the experiment. That the incidence of attack has been considerably lowered is indicated by the fact that the attendance in schools during the malaria season improved from 70% in 1931 to 85% in 1935, but whether plasmoquine alone is a reliable prophylactic against the transmission of malaria has still to be definitely proved.

Acridine Derivatives as Antimalarials.

Browning *et al* (*J. Path. Bact.*, 1924, *27*, 121 ; *Proc. Roy. Soc.*, 1922, *93*, 329) made an extensive study of the antiseptic

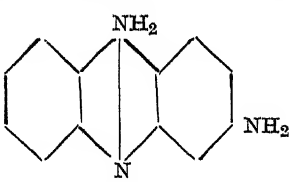
action of acridine and quinoline dyes. From their work it would appear that the introduction of amino groups in the two benzene rings A and B or at 9 increases antiseptic action (cf. acridine and diamino acridine or 2-ethoxy-6 : 9-diamino acridine).



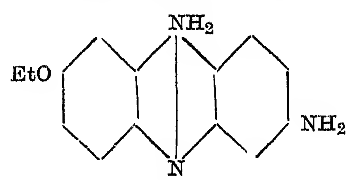
(XI)

Conversion to acridinium derivatives also increases antiseptic properties (cf. 3 : 6-diamino acridine and 3 : 6-diamino acridinium hydrochloride (proflavine) or 3 : 6-diamino acridinium methochloride (trypaflavine—XI).

Although alkylation of a single amino group increases antiseptic action in some cases, simultaneous mono-alkylation of each amino group diminishes antiseptic action, while acylation of the amino group or the introduction of an alcoholic radical into the amino group destroys antiseptic action altogether. Introduction of a phenyl group in position (9) decreases efficiency. Jodlbauer and Salvendi (*Arch. intern. pharmacodynamie*, 1905, *15*, 223) found 9-phenyl acridine less antiseptic to paramoecia than 3-methyl acridine. Langer (*Z. ges. expt. med.*, 1922, *28*, 45 and earlier papers) found that the antiseptic action of acridine dyes increases with the molecular weight. An increase of dispersion increases antiseptic action, whilst a decrease has the opposite effect and independent of chemical structure, such physical properties as surface tension and those which are functions of the degree of dispersion determine pharmacological action in the acridine series. As we have noticed in the case of cinchona alkaloids, the presence of groups such as alkoxy which increase the permeability of the drug often profoundly affects the pharmacological action in this series also (cf. 6 : 9-diamino acridine and 2-ethoxy-6 : 9-diamino acridine—rivanol) :—

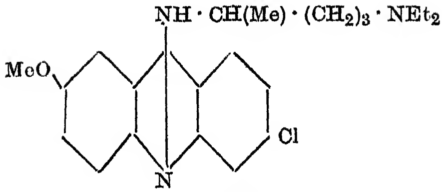


(XII)



(XIII)

Mietsch and Mauss have prepared substituted alkylamino-acridine derivatives of which the substance represented by the structure XIV called ‘ atebrin ’ has been found to be a valuable antimalarial.



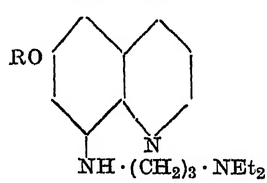
(XIV)

In his experiments with birds infected with *plasmodium præcox*, Kikuth (*Deutsch. med. Wochenschr.*, 1932, *58*, 530) found it to be less toxic than plasmoquine, from which it differs in that it does not affect the gametes but kills the schizont forms. Thus, it is complementary to plasmoquine. Good results have been reported in the treatment of tertian malaria by atebrin. Green (*Lancet*, 1932, *222*, 826) found that atebrin compares favourably with quinine in destroying the parasites from blood. Atebrin acts directly on the trophozoites of all three types of the parasites but has no action on the crescents of the subtertian type. The yellow discoloration of the skin, noticeable after the administration of atebrin has nothing to do with icterus as was formerly supposed. The annual report of the Public Health Commissioner to the Government of India (1932) states that no toxic effects of any importance have been noticed after the administration of atebrin. Atebrin used alone is quite sufficient to eradicate the asexual forms of the parasite and hence can effect a clinical cure of malaria.

A drug having true prophylactic effect must possess a specific action on the sporozites. Neither plasmoquine nor atebrin, however, possesses this action. Certain claims have been made for musonate of atebrin but at present they lack confirmation.

Walls (*J.*, 1935, 1405) has synthesized a phenanthridine derivative containing the same basic side chain as atebrin but pharmacological tests show that it is less active than atebrin which is its acridine analogue.

Another competitor of atebrin is the Russian product called plasmocide (XV) (Tarejew, *Bull. Soc. Path. exot.*, 1933, *26*, 1037 ; Tareer, *Med. Parasit and Parasitie Dis.*, 1933, *2*, 189).

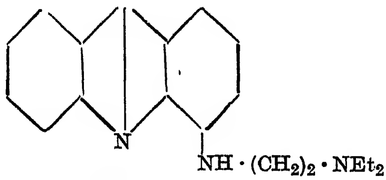


(XV)

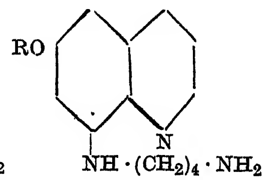
A large number of investigations have been carried on the possibilities of the beneficial administration of plasmoquine or plasmocide (antigametocides) in conjunction with quinine or

atebrin (antischizonts) but a final verdict must be awaited until more data are available.

Clemo and Hook (*J.*, 1936, 608) have recently prepared the simple acridine derivative (XVI) but it is not yet known how far its properties resemble atebrin.



(XVI)



(XVII)

Of the numerous attempts that have been made to prepare substances of the type of plasmoquine, the work of Robinson and Baldwin (*J.*, 1929, 2959) calls for particular attention. Robinson and Meisel (*J.*, 1934, 1267) showed that the most effective compound of this type was 8-(δ-aminobutyl amino)-6-methoxyquinoline (XVII) ; Strukow and Magidson (*Arch. Pharm.*, 1933, *271*, 569) also prepared its diethyl analogue. Fourneau (*Ann. Inst. Pasteur*, 1933, *50*, 731) has made a systematic study of the compounds related to plasmoquine in bird malaria and concludes that—

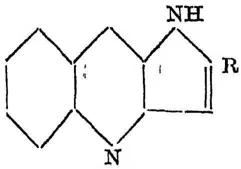
(*a*) In compounds of the plasmoquine type with an amino alkylamino group in position 8, greater activity is displayed when the alkyl of the latter group is a straight chain than when it is branched. This conclusion is confirmed by Robinson and Meisels' compound (XVII) which possesses the greatest efficacy of that series.

(*b*) The alkoxy group in position (6) is not indispensable but is always favourable to therapeutic action. Ethoxy is less favourable than methoxy. It has already been explained that the difference in action between quinine and cinchonine is due to the difference of solubility of the drugs in erythrocytes ; a similar reason may be responsible for the favourable therapeutic action of 6-methoxy compounds in the quinoline series.

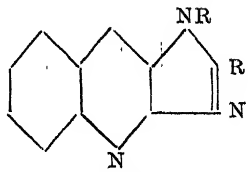
From the foregoing summary it would appear that neither plasmoquine nor atebrin has true prophylactic action. A drug has yet to be discovered which will have curative value in subtertian infection. In recent years a large amount of work has been done in seeking an ideal antimalarial. Although the experiments have not yielded positive results, still some purpose has been served in that certain apparently reasonable postulates have been investigated and eliminated.

I shall now give a resume of synthetic work carried out in the last six or seven years.

Mrs. Robinson (*J.*, 1929, 2948) has prepared quinolino-pyrrols of the type (XVIII), whilst Narang and Ray (*J.*, 1931, 976) prepared a quinoline fused with a glyoxaline ring (XIX).

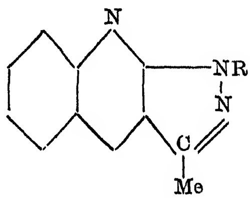


(XVIII)



(XIX)

This latter substance had the requisite antiseptic properties as tested against paramoecia but the compounds of this series had very feeble basicity and did not give stable salts. Narang, Ray and Singh (*J. Ind. Chem. Soc.*, 1934, *11*, 427) have prepared a series of pyrazolino quinolines of the type (XX) of which the pharmacological properties are still under investigation.



(XX)

Gunn and Marshall (*Proc. Roy. Soc. Edin.*, 1920, *15*, 145) have indicated that the alkaloid, harmaline, although inferior to quinine, possesses curative values in acute malaria (50% of the cases) while harmine, valueless in acute malaria, prevented the recurrence of attacks in cases where a quinine tolerance had been developed. This indicates that the search for an anti-malarial need not be confined to the quinoline group. A substance increasing the defence mechanism of the body may also act as an antimalarial and it seems probable that, apart from any antiplasmodial action they may possess, the harmala alkaloids possess this very property.

Aggarwal, Qureshi and Ray (*J. Amer. Chem. Soc.*, 1932, *54*, 3988) prepared some pyrryl indoles having a partial similarity with harmine structure but these compounds have no special merit. Chatterji (*J.*, 1929, 2965) has prepared β-benzoiminazoyl ethyl amine but found that the compound has no antimalarial properties. Sheshadri (*J.*, 1929, 2952) has prepared some amino alkyl quinolinium salts, Kermack and Smith (*J.*, 1930, 1256) the 4-piperidino and 4-piperazino derivatives of quinoline and

Brahmachari and Das Gupta (*J. Ind. Chem. Soc.*, 1932, *9*, 37, 207) some alkyl aminoquinolines.

Cotarnine Derivatives.

In the report of the Opium Commission of 1885 (Government of India), it is stated that opium may have an antimalarial action. This conclusion was based on the close relationship that was observed between the local consumption of opium and non-prevalence of malaria in certain districts. That there may be some real connection is indicated by the fact that narcotine somewhat resembles quinine in its tonic and antiperiodic properties. Dr. Palmer (1857-59) treated 546 cases of malaria with narcotine ; of these 541 are stated to have been cured and 5 died. Moreover, he tried the alkaloid in a large number of cases and summed up the report of his experiments by the statement that 70% of the cases of fever were permanently arrested at the second paroxysm after the administration of narcotine ; in 20% the arrest was equally certain but not so rapid and in 10% of the cases the medicine did not show any curative results. Dr. Gordon (*Indian Annals of Medical Science*, Vol. VII) confirmed these results in 194 cases but seven did not respond to the narcotine treatment. From these data, it would appear that narcotine has some antimalarial action, but Chopra and Knowles (*Ind. J. Med. Res.*, 1930, *18*, 5–13) arrived at the conclusion that narcotine did not show any prophylactic or curative effects in malaria and that the alkaloid, even in such large doses as 10–15 grains daily, showed no effect on the parasites of any forms of malaria circulating in the peripheral blood.

At the suggestion of Prof. H. B. Dunnicliff, the Central Board of Revenue provided material and funds for an investigation at Lahore on the preparation of a possible antimalarial from narcotine. Anhydrocotarnino-resorcinol was found to be highly toxic to paramoecia ; so much so that its antiseptic properties compared very favourably with an equivalent dilution of quinine. Moreover, this compound had very definite antipyretic action in which respect it was even better than quinine and aspirin when tested in pyrexia induced by *B. Coli Communis* broth. The acetyl derivative of the compound acts on the uterus of the rabbit, isolated or *in situ*, causing a profound tonic contraction, which does not relax after repeated washing with Ringer's solution for some considerable time. The possibility of employing this compound clinically is being explored.

It seems that this derivative of cotarnine resembles quinine in many respects but, on clinical trial on malarial patients it fell short of expectation. It is true that, soon after the administration of this drug, the parasitic count decreased considerably and a rapid fall of temperature was observed but the effect totally disappeared in a short time. So we are unable to

say at present if an antimalarial is likely to be found among the derivatives of cotarnine. The present indications are that it is very unlikely that a potent antimalarial will be found in this series.

Ahluwalia, Kaul and Ray (*J. Ind. Chem. Soc.*, 1933, 10, 197) prepared some cotarnino-pyrazolones but these also showed no antimalarial properties. These authors have described some cotarnino-quinolines which have not yet been fully investigated. Recently, Clemo, McIlwain and Morgan (*J.*, 1936, 610) have described some α-picolyl-*iso*quinolines, analogous to the cotarnino quinolines of Ahluwalia, Kaul and Ray (*loc. cit.*) as possible antimalarials but it has not been stated if they possess the property.

Other Alkaloids.

On account of the fact that the bark of various species of *Alstonia* is reputed to possess antimalarial properties, Sharp (*J.*, 1934, 287) undertook a detailed investigation of its alkaloids. He isolated a new alkaloid alstonine in a pure condition but neither echitamine nor alstonine showed any antimalarial properties in avian malaria.

Organometallic Compounds.

The recent use of salvarsan, stovarsol and mercuro-chrome in benign tertian malaria suggests that this line of enquiry should yield profitable results.

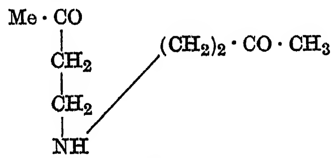
Conclusions.

A review of the recent work on antimalarials leads to the conclusion that in spite of earnest endeavour we have yet to improve upon quinine and other cinchona alkaloids. The same observation may be made about other naturally occurring substances such as strychnine, hyoscyamine, adrenaline, emetine and so on in their respective spheres. Their derivatives or synthetic analogues have proved useful but have by no means replaced them.

The organic chemistry of the 'test tube' has very little parallelism with the mechanism operating in the living cells. What molecular species and reagents nature employs in building up these highly complicated beneficial products has not yet received complete solution in most cases. The chemistry of the test tube has so far failed to effect a synthesis of quinine and its allies. 'There is a tendency' as Robinson has remarked 'to explain this failure by the assumption that plants have at their command enormously powerful reagents, which induce transformations impossible to reproduce in the laboratory. To a certain extent this must be true but it is probable that this

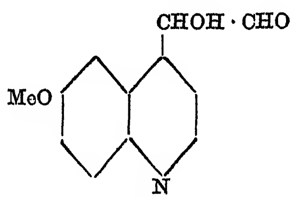
aspect has been exaggerated'. Robinson's brilliant work on the pyrrolidine group of alkaloids and his synthesis of harman from tryptophan and alanine under natural conditions are examples of the simulation of phytochemical reactions in the laboratory. Robinson's (with Suginome's, *J.*, 1932, 304 and with King's, *J.*, 1932, 1433) synthesis of the eserine ring system runs parallel to his suggested phytochemical mechanism, thus imparting great importance to his views on the synthesis of cinchona alkaloids in plants.

Robinson believes the diketone (XXI) to be the origin of the meroquinine half of cinchona alkaloids. This is formed from formaldehyde, ammonia and an acetone derivative like acetoacetic acid containing a reactive methylene group.

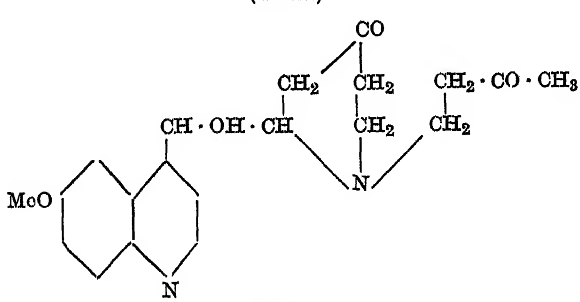


(XXI)

The quinoline derivative (XXII) undergoes carbinolamine condensation to give (XXIII).



(XXII)



(XXIII)

The compound (XXIII) then undergoes an internal aldol condensation to give the corresponding cyclol which, by loss of water and subsequent reduction and further loss of water, is converted to quinine.

The quinoline derivative (XXII) is supposed to be derived from quinic acid, a natural constituent of cinchona bark.

It will be seen that the above mechanism is an extremely plausible one. Is it too much to hope that one day it will receive confirmation at the hands of an inspired investigator, thereby solving a great chemical and sociological problem ?

Simonsen in his Presidential address to the Science Congress in 1928, deplored the fact that very little work has been undertaken on plant products in India, a country eminently suited for that type of work. Since then greater interest has been taken in this branch of chemistry and of late some work of importance has been done in this country. The two indigenous systems of medicine serve as good guides in the search for pharmacologically important products from our natural sources. Siddiqui's work in Delhi on the isolation of the alkaloids of *Rauwolfina Serpentina* is a case in point. I am conscious of the fact that the mere isolation of an alkaloid or the routine determination of its constituent groups may not mean a great deal. But there is need for the preliminary experiments of this nature before more ambitious work on the determination of structure by analytical and synthetical means could be undertaken. Valuable work on the constitution of alkaloids has been done at Dehra Dun by Krishna and his colleagues, Ghosh has also published important work from the Tropical School of Medicine, Calcutta, and at other centres also there has been some activity in this field. This is a good and creditable beginning. It augurs well for the future that in spite of handicaps, a considerable amount of valuable work is being turned out by the Universities.

The financing of research is a problem which requires early solution. The universities themselves are unable to embark on any elaborate research programme owing to the present state of their finances.

The majority of the universities mainly depend on (*a*) fees collected from the students, (*b*) charitable bequests, and (*c*) Government grants. Except in a few isolated instances there is a distinct tendency for the public to ignore the universities in their charity. I am well aware of the princely donations of the late Sir T. N. Palit and the late Sir R. B. Ghosh to the Calcutta University. Recently 'the father of the Indian Chemists', Sir P. C. Ray has made a commendable donation towards further research work in this country. His words in this connection are well worth serious consideration of our industrialists. Let us hope they would be inspired to emulate his noble example. The life-long service rendered by Sir P. C. Ray to the cause of chemistry is unique, and this country is blessed to have a man of his stamp.

The prevailing economic distress makes people feel that the salvation of the country lies in commercial and industrial chemistry. Therefore, the chemists engaged in research work

are not quite so much before the public eye. In some quarters there is noticed a distinct lack of interest in the work of researchers. An eminent cotton magnate recently remarked that he did not believe in measuring lengths and breadths of molecules. It is not realized that a man who has a thorough grounding in any branch of pure chemistry is better fitted to tackle an industrial problem than one who has been taught 'how to make things' only. The confidence reposed in Bhatnagar, a Physical Chemist, by Messrs. Steel Bros. in dealing with their problems in petroleum technology at Lahore is a case in point. The teaching and practice of technical chemistry cannot be divorced from research work. Any one who helps the cause of chemical research would be doing a national service, for chemistry is the key science whether in peace or in war, and 'chemical research is synonymous with national welfare' as Emil Fischer truly remarked some years ago.

SECTION OF CHEMISTRY

Abstracts

Inorganic Chemistry

1. Some compounds of boron, hydrogen and oxygen.

R. C. RAY, Patna.

When magnesium boride is treated with water, out of contact with air, a powerfully reducing solution is obtained. From this solution, two isomeric compounds of the formula, $K_4H_2B_2O_2$ together with two other compounds having the formulæ, $K_4H_2B_2O_2$ and $K_2H_2B_2O_2$, respectively, have been isolated. The constitution of these compounds has been discussed. The mechanism of their formation and their relationship with boron hydrides have been suggested.

2. New compounds of gallium. Part II.

P. NEOGI *and* S. K. NANDI, Calcutta.

A hydrated oxide Ga_2O_3,H_2O, chlorate, bromate, iodate, metaphosphate, phosphate and basic phosphates of gallium have been prepared.

3. Substituted cyano-cobaltiates. Aquo-pentacyano-cobaltic acid and its salts.

P. RAY *and* N. R. DUTT, Calcutta.

In continuation of the investigation on the substituted cyano-cobaltiates by one of us (P.R., *Zeit. anorg. u. allg. Chem.*, 1931, **199**, 353; 1933, **211**, 173; 1934, **220**, 153), aquo-pentacyano-cobaltic acid and its salts have now been prepared and their properties studied. The parent aquo-compound was obtained by the oxidation of previously described thiosulphato-pentacyano-cobaltiate with hydrogen peroxide in an almost neutral solution. Besides the free acid, alkali, alkaline-earth and some heavy metal salts have been described. The yellow silver salt, on dehydration, gives a blue penta-co-ordinated practically diamagnetic compound. This is rather unique. The free acid itself is, however, not very stable.

4. Resolution of co-ordinated inorganic compounds. Part II.

P. NEOGI *and* K. L. MANDOL, Calcutta.

Twenty-four co-ordinated compounds of cadmium containing: (1) two molecules of ethylenediamine and one molecule of propylenediamine, and (2) one molecule of ethylenediamine and two molecules of propylenediamine have been prepared and the optical rotations of the active compounds have been measured.

5. Studies in the pseudo-alums.

P. B. SARKAR *and* B. C. RAY, Calcutta.

A systematic study of the complete poly-therms of various sulphates of magnesium group of metals with aluminium sulphate and water has been undertaken.

6. The action of hydrogen sulphide on sodium nitrite and lead nitrite.

H. B. DUNNICLIFF, SARDAR MOHAMAD, *and* MAHARAJ KISHEN, Lahore.

The reduction of sodium nitrite in solution yields sulphur and the polysulphides of ammonium and sodium but not hydroxylamine. Its reduction in the solid state produces an explosive yellow compound which appears to have the composition $NaNO_2H_2S$.

The reduction of lead nitrite gives nitrous oxide, nitric oxide, nitrogen hydroxylamine, sulphur, ammonium sulphate and lead as sulphide and sulphate. The reduction is apparently controlled by the catalytic action of nascent nitrous acid.

7. Polymerisation of sulphur monoxide.

B. SANJIVA RAO *and* M. R. ASWATHNARAYANA RAO, Bangalore.

Further work on sulphur monoxide in tetrachlorethylene solution (cf. B. S. Rao and M. R. A. Rao, *Current Sci.*, 1935, **6**, 406) has given evidence of polymerisation of the monoxide to form thiosulphuric anhydride. The monoxide when adsorbed on silica gel yields the polymerised form as revealed by certain experiments.

8. Constitution of hypo-nitrous acid from physico-chemical studies.

P. B. SARKAR, B. C. RAY, *and* J. GUPTA, Calcutta.

9. Constitution of iodic acid.

M. R. NAYAR *and* L. N. SRIVASTAVA, Lucknow.

Aqueous solutions of the acid of 14 different dilutions varying from 0·01N were prepared and their physical properties investigated. The specific property of the solute is determined from the mixture law equation:

$$P_{soln.} = P_{solvent}\,(1\text{-}x) + P_{solute}\,(x)$$

where P denotes the property like density, viscosity, refractive index, etc., and (x) and $(1\text{-}x)$ are the molecular fractions of the solute and solvent respectively.

When P_{solute} is plotted against the concentration, the graph is found to be not a straight line, nor even a continuous curve. In the case of viscosity, for example, there are three parts of the curve (2nd and 3rd convex towards concentration) intersecting at 0·04N and 0·1N. The minima correspond to 0·05—0·06N and 0·4N—1·0N.

Such a behaviour was expected from freezing point and other experiments (*Zeit. anorg. Chem.*, 1934, **220**, 163) and may be explained by the reaction :

$$(HIO_3)_3 \rightleftarrows \tfrac{3}{2}(HIO_3)_2 \rightleftarrows HIO_3 \rightleftarrows H^+ + IO_3^-$$

10. Studies in hydrates of zinc sulphate in presence of sulphuric acid.

N. K. Joshi, Bombay.

(Communicated by P. M. Barve, Bombay.)

It is well known that the hydrates of a salt are stable only within a certain range of temperature and that in general as the temperature rises, progressively lower and lower hydrates are formed. It is difficult to work at high temperatures and examine the various hydrates formed.

It is reported (H. W. Foote, *J. Amer. Chem. Soc.*, 1915, 37, 290) that extremely soluble acids like hydrochloric, sulphuric, nitric or extremely soluble salts like magnesium chloride have a dehydrating effect. Therefore it may be possible to observe the formation of several hydrates—stable at different temperatures by the addition of varying amounts of an acid (or a neutral salt) to the solution at a fixed temperature. For zinc sulphate the only hydrates so far reported are the hepta, hexa and mono hydrates. The methods employed were the determination of (*a*) the solubilities at various temperatures, and (*b*) vapour pressure. It is possible that some of the hydrates might have escaped detection if their transition range was very small. But by progressive small additions of sulphuric acid we should be able to detect the formation of any intermediate hydrates. With this in view, all the possible hydrates of zinc sulphate at 30°C and 45°C were studied in presence of varying amounts of sulphuric acid. The method adopted was Schreinnemaker's 'residue' method (*J. Amer. Chem. Soc.*, 1924, **46**, 1766) for the determination of the solid phase in the solubility bottles designed by N. Campbell (*J. Chem. Soc.*, 1930, 179).

It has been found that the addition of sulphuric acid considerably diminishes the solubility of zinc sulphate, whilst the solid phase undergoes a variation identical with that produced by increase of temperature in pure aqueous solutions. As the concentration of the acid is increased, the hepta, hexa and mono-hydrates become the only stable solid phase in equilibrium. Investigation of hydrates of other salts by this method is in progress.

11. Hydrolysis of uranyl salts.

Balwant Singh, G. Ahmad, *and* H. B. Dunnicliff, Lahore.

The hydrolysis of uranyl nitrate, uranyl sulphate and uranyl acetate has been studied at 30°C by the electromotive force method, using the quinhydrone electrode. The order of salt hydrolysis has been found to be as uranyl nitrate>uranyl sulphate>uranyl acetate. The degree of hydrolysis increases with dilution. The results obtained compare well with the degree of hydrolysis determined by Bruner (*Zeit. physikal. Chem.*, 1900, **32**, 133) at 40°C for the nitrate and the sulphate by the sugar inversion method.

12. An examination of a very insoluble phosphate extracted from monazite obtained from Orissa. Part II.

C. B. Roy *and* S. B. Roy, Sabour.

The present paper is a continuation of the work described in (1) *J.S.C.I.*, 1933, 745, and (2) *Zeit. anorg. Chem.*, 1933, **216**, 203.

The refractory phosphate referred to in (2) has been further investigated. Attempts at further purification of the base led us to the clue that the chloride could be divided into two portions : (*a*) colourless crystals insoluble in conc. hydrochloric acid, and (*b*) a yellow portion soluble in conc. hydrochloric acid. After repeated treatment, the solution of the yellow portion was so far purified that by spectroscopic examination, kindly undertaken by Profs. K. Prasad and D. K. Bhattacharya, Science

College, Patna, there was no evidence of the presence of Zr, Hf or Ti. We do not think, however, that the presence of traces of Ce indicated by spectroscopic evidence, still tenaciously retained after our exhaustive treatment, can fully explain the peculiarities of the base mentioned in our paper (2).

Further examination of (*a*) and of (*b*) by spark spectra for which fresh quantity of monazite has to be broken up again and subjected to the laborious operation described, is in progress.

13. Influence of light on iodine vapour at 250°.

T. SURYANARAYANA, Waltair.

Iodine vapour enclosed in an evacuated soft glass bulb kept at a temperature of 250°–300°C is exposed to light from a 1,000 watt Tungsten filament lamp. After two days white solid substance is found deposited on the glass wall. On breaking the bulb the white substance became a brown liquid. The nature of the white substance is under investigation and it is supposed to be silicon iodide.

14. Decomposition of the sulphates of calcium, strontium and barium.

S. M. MEHTA *and* H. A. COOPER, Bombay.

The decomposition of the sulphates of calcium, strontium and barium in the presence of different amounts of boric anhydride has been studied at temperatures between 900° and 1100°C. It is found that these substances decompose to give mostly sulphur trioxide with a small proportion of sulphur dioxide. It has been possible to effect nearly ninety-two per cent decomposition of calcium sulphate at a temperature of about 1000°C. The effect of the addition of iron, nickel and carbon on the decomposition of calcium sulphate has also been investigated and it is found that the temperature of decomposition is appreciably lowered by the addition of these substances. The decomposition of the alkaline earth sulphates under identical experimental conditions has been compared. It is suggested that the residue may be utilized to give (i) glass, (ii) acid, or (iii) borax.

15. Electro-deposition of chromium from potassium dichromate baths. Part III. In presence of borate.

M. A. ALI *and* S. HUSSAIN, Hyderabad (Deccan).

Electrolysis of baths containing potassium dichromate and a high concentration of boric acid with a low current density at 40°C yielded white tenacious deposits of chromium. The current efficiency was lower than in the case of baths containing potassium dichromate and sulphuric acid or acetic acid. When dichromate was substituted by chromate or boric acid by borate, no white deposit was obtained. Change of distance between the electrodes had considerable effect on the deposit. Lead anodes were as good as platinum anodes.

16. Electro-deposition of copper on glass surfaces.

S. S. JOSHI *and* S. S. KULKARNI, Benares.

It has been found that considerable difficulties exist in the preparation of copper films on glass, when produced by the reduction of suitable copper salts. These are chiefly in respect of the chemical purity, homogeneity and the optical regularity of the reflecting surface. Satisfactory results were, however, obtained when silver films produced by some of the well known chemical methods were used as a conducting base, for

subsequent electro-deposition from copper baths. The usual cupro-cyanide method (also that involving the use of copper sulphate) could not be employed, as this weakened the initial silver base. In certain ranges of temperature and concentrations for which data have been worked out, copper acetate and cuprammonium solutions (both when copper salts, copper hydroxide, or even when metallic copper in the presence of oxygen, were treated with strong ammonia) gave stable copper films with characteristic mirror properties, which have been studied.

17. Elementary and mixed metallic films by electrodeposition on glass surfaces.

S. S. JOSHI *and* N. HANUMANTHA RAO, Benares.

Detailed studies have been made of: (*a*) the conditions for silver deposition from solutions as dilute as 0·01 per cent silver nitrate, (*b*) the chemistry of the pre-treatment of the glass surface, (*c*) the kinetics, the spectral sequence of the play of colours during the production of the silver mirror, (*d*) the influence of temperature, (*e*) surface conductivity, (*f*) microscopic examination of the surface structure of the mirror, (*g*) the effect of extraneous materials in small amounts, e.g., potassium hydroxide, certain electrolytic coagulants, gelatin, etc. Data are given for the absorption limits of these silver films both when pure, and when superimposed with extremely thin deposits of gold and nickel produced electrolytically. Interesting results were obtained on the mobilization of the particles at low temperatures (about 300°C.) and the corresponding shift in the absorption limits.

18. A new method for the estimation of bromides.

M. R. VERMA, P. L. KAPUR, *and* M. ANWAR-UL-HAQ, Lahore.

The bromide solution is treated with a mixture of 10% chromic acid and 10% nitric acid and bromine so liberated is extracted repeatedly with carbon tetrachloride. The estimation is carried out by treating the extract with potassium iodide and titrating the liberated iodine against sodium thiosulphate.

19. Analysis of type metal.

P. R. SUBBARAMAN *and* K. R. KRISHNASWAMI.

Lead-tin-antimony alloys offer considerable difficulties in analysis. The methods so far suggested are either tedious or involve special apparatus.

Several alloys of lead, tin and antimony of known composition have been prepared and their analyses carried out by different procedures with a view to evolve a convenient and reliable method. The results obtained are described in the paper.

20. Electrometric titration of dibasic acids.

C. T. ABICHANDANI *and* S. K. K. JATKAR, Bangalore.

The differential titration curves for oxalic, malonic, succinic and adipic acids by sodium hydroxide solution (N/10) containing small quantities of carbonate revealed the pronounced negative values near the end point and minor inflexions at the half neutralization points, the values of the former being inversely proportional to the strength of the acid. The titration curve of adipic acid is not similar to that of succinic acid as reported by Chandler

21. Tourmalines from the Mysore state.

K. Y. SREENIVASA, Iyengar.

Various specimens of tourmaline obtained from the Director of the Mysore Geological Department have been subjected to careful chemical analysis and the results obtained are mentioned and discussed in this paper.

An account is given of the difficulties met with in the determinations of boron, fluorine and water in tourmaline, and also of the precautions to be taken to obtain reliable results.

22. Reduction of iron content of native pyrolusite.

S. VENKATASUBBA RAO *and* K. R. KRISHNASWAMI.

The Indian deposits of pyrolusite are too high in iron to satisfy some specific commercial requirements. Samples from a deposit in Mysore State carrying 85 per cent. MnO_2 and 3·5 to 4 per cent. of Fe were submitted to various methods of treatment, e.g., Wilfley table, electromagnetic separator and chemical reagents.

The results obtained are discussed in the paper.

Physical Chemistry

23. Decomposition of nitric oxide under silent electric discharge.

S. S. JOSHI *and* K. C. SHRIVASTAVA, Benares.

A detailed study of this decomposition has been made (under a given group of electrical factors) of the influence of the addition of moisture, N_2, NO_2, H_2O, Cl_2, Br_2, I_2, H_2 and SO_2 in varying proportions. The decomposition of nitric oxide in the discharge is retarded to an extent which increases by increasing the proportion of the foreign gas. The 'electron affinity' of the latter has been found to be an important determinant of this power of retardation. The current through the reaction space varies discontinuously indicating intermediate changes; of these one has been established to be the formation and subsequent decomposition of nitrogen peroxide. Measurements have been made of the 'threshold potential' during the complete decomposition of the gas both when pure and in the presence of the above mentioned foreign gases.

24. The hydrogen-chlorine interaction under electric discharge.

S. S. JOSHI *and* P. N. BHARGAWA, Benares.

The principal data in the literature for the production of this reaction refer to the use of α-rays, radiations of different frequencies and heat (dark reaction). We have studied this under the influence of electrical discharge due to alternating fields of low frequencies. Measurements were made of (*a*) the potential applied to the reaction vessel, (*b*) the current flowing through the latter during the reaction, and (*c*) influence of independently present excesses of chlorine and of hydrogen, and of small proportions of ammonia, oxygen on the course, the rate of the reaction and its 'threshold potential'. The ionization current was found to diminish during the reaction and very large values obtained for the number of hydrochloric acid molecules produced *per ion*. The reaction was found to be explosive except with low pressures of the gas mixture and in the presence of a sensible excess of hydrogen.

25. Decomposition of hydrogen sulphide by electric discharge.

S. S. Joshi *and* R. G. Khalsa, Benares.

The reaction has been studied under the spark and also silent discharge under different conditions of the applied potential, the gas pressure, the interelectrode distance, the frequency of the A.C. supply and so on. Hydrogen and free sulphur were the only products at any stage of the decomposition. The latter is produced in a peculiar grey form. The kinetics of its crystal growth under the discharge has been studied microscopically. Since the reaction does not produce any change of pressure, its course was followed by the analysis of the composition of the decomposition mixture at different stages. At a constant applied potential the percentage decomposition was found to diminish with the gas pressure in agreement with a theory developed by Elliott, Joshi and Lunt (*Trans. Farad. Soc.*, 1927, **23**, 57). The current varies in a characteristic manner during the progress of a given decomposition. It increased first rapidly and then slowly (latter depending upon the gas pressure) and finally became constant, with the completion of the decomposition. The 'threshold potential' decreased during the decomposition, presumably due to the diminution of hydrogen sulphide. Results are given for the M/F values under various conditions.

26. Raman spectrum of phenols from *Thymus serpyllum.*

B. Sanjiva Rao, Bangalore.

It was not found possible to determine by any known method a second phenol present in *Thymus serpyllum* oil, carvacrol being the main constituent. Raman spectrum of the different phenolic fractions has shown that the other phenol present is thymol.

27. Mechanism of inhibition of fluorescence.

K. S. Gururaja Doss, Bengalore.

A critical study has been made of the available experimental data on inhibition of fluorescence. On the assumption that inhibition is due to collisions of the second kind (cf. Jette and West, *Proc. Roy. Soc.* 1928, **A121**, 299) a formula has been obtained and found to explain quantitatively certain cases of inhibition brought about by ions. The autoinhibition of fluorescent substances, however, can satisfactorily be explained only on the basis of polymerization.

28. An X-ray investigation of the crystals of *p*-azotoluene.

Mata Prasad *and* M. R. Kapadia, Bombay.

The crystals of *p*-azotoluene belong to the monoclinic prismatic class, and the axial ratio found by the measurements of the interfacial angles is a : b : c = 2·1768 : 1 : 1·9674; $\beta = 90°16'$ (cf. Groth, V, p. 66). The X-ray study of the crystals has given the following lengths for the dimensions of the unit cell :

$$a = 12{\cdot}00\text{Å},\ b = 4{\cdot}851\text{Å},\ c = 9{\cdot}703\text{Å}.$$

These lengths have been found to give axial ratio which is in better agreement with that calculated from the interfacial angles measured by Groth. The unit cell belongs to the space group C^5_{2h} and contains two molecules. These facts show that the molecules in the unit cell have a centre of symmetry. The probable position of the molecules in the unit cell has been determined from the relative intensities of reflection of the observed planes.

29. A preliminary X-ray investigation of the crystal structure of hydroazobenzene.

JAGADISH SHANKER *and* MATA PRASAD, Bombay.

The crystals of hydroazobenzene belong to the bipyramidal class of the orthorhombic system. The axial ratio as obtained from crystallographical measurements is :

a : b : c=0·9787 : 1 : 1·2497 (cf. Groth, V, p. 59).

The crystals have been studied by the rotating crystal method. The dimensions of the unit cell are

$$a=7{\cdot}35\text{Å},\ b=7{\cdot}50\text{Å},\ c=18{\cdot}55\text{Å}$$

which give the axial ratio in agreement with that recorded in Groth except that (c : b) is doubled. The number of molecules per cell are found to be four. Since the least number of asymmetric units necessary to complete the symmetry of the point group Q_h is eight, the results indicate that there is some internal symmetry in the molecule inside the unit cell. The probable space group has been discussed. Intensity measurements are in progress.

30. An X-ray investigation of the crystals of (i) diphenyl disulphide, and (ii) diphenylene disulphide (thianthrene).

MATA PRASAD *and* B. H. PEERMAHOMAD, Bombay.

(1) The crystals of diphenyl disulphide belong to the rhombic system and crystallographic measurements give the ratio $a : b : c = 0{\cdot}6821 : 1 : 0{\cdot}4987$ (cf. Groth, V, p. 33). The crystals were studied by the rotation and oscillation method. The dimensions of the unit cell are :

$$a=8{\cdot}10\text{Å},\ b=23{\cdot}84\text{Å},\ c=5{\cdot}61\text{Å}$$

which shows that the ratios $a : b$ and $c : b$ are halved. The number of molecules per cell calculated from the dimensions of the cell and the specific gravity of the crystals (found to be 1·339) is four. The probable space group which would fit in with the observed halvings has been discussed.

(2) The crystals of thianthrene belong to the monoclinic prismatic class and

$$a : b : c=3{\cdot}7941 : 1 : 1{\cdot}1807;\ \beta=105°48'$$

(cf. Groth, V, p. 34). The X-ray rotation photographs give

$$a=22{\cdot}86\text{Å},\ b=6{\cdot}0\text{Å},\ c=14{\cdot}66\text{Å};\ \beta=105°48'$$

which show that the ratio of $c : b$ is doubled. The number of molecules per unit cell is eight. The molecules in the cell are asymmetric.

31. Photo-decomposition of silver halides.

S. S. BHATNAGAR, M. R. VERMA, *and* I. C. GUPTA, Lahore.

Magnetic susceptibility measurements of halides of silver at various stages of photo-decomposition under halogen absorbers like potassium nitrite, water, gelatine, carbon tetrachloride, etc. were carried out. The results suggest that the course of photodecomposition is represented by the equation :

$$2AgX=2Ag+X_2$$

where X is the halogen.

32. Transformation of chromic chloride in dilute solutions in the dark and ultra-violet light.

D. S. Datar *and* M. Qureshi, Hyderabad (Deccan).

The transformation of the dark green chromic chloride in a 0·01 molar solution in the dark was followed by measuring extinction co-efficient, P_H value and electrical conductivity at definite intervals of time. A state of equilibrium is reached in about six hours and a half. The peak of the absorption band of a freshly prepared solution lies at about 6400Å, while the position of maximum absorption in the case of the equilibrium mixture is near 5750Å. The results indicate that it is not a case of a simple and direct isomeric change of the dark green variety into the violet form, but that of a complex change taking place in several stages and accompanied by hydrolysis.

Exposure to ultra-violet light accelerates the rate of transformation.

33. Absorption spectra of binary liquid mixtures.

S. S. Bhatnagar, P. L. Kapur, *and* M. D. Rajpal, Lahore.

The absorption spectra of mixtures of nitrobenzene and *o*-nitrotoluene with (*a*) aniline, (*b*) *o*-toluidine, (*c*) *m*-cresol, (*d*) toluene, and (*e*) *m*-xylene has been studied. As the nitro-bodies show general absorption in ultra-violet region even when present in small thicknesses the study has been restricted, therefore, to the visible region only. Binary mixtures of hydrocarbons with nitro-bodies give the superimposed spectrum of the components, of *m*-cresol with nitro-bodies show slight displacement and of amines with nitro-bodies exhibit large displacement of the absorption spectrum towards the red region. The slight displacement has been shown to be due to the dipolar association whereas the large shift has been attributed to the chemical association of the components.

34. Photo-electric threshold and latent heat of fusion.

B. N. Sen, Burdwan.

A formula has been proposed for the calculation of the photo-electric threshold wavelength from the latent heat of fusion of the metals concerned on the basis of Pauli-Sommerfeld theory of degenerate electron-gas for the metallic state with the modification that in the solid state the electrons cannot move in a force-free space and their mobility is governed by the least distance between the atoms. The formula may be represented thus:

$$\lambda_0 = k \, D \log (L)$$

where λ_0 is the threshold wavelength, D, the distance of the closest approach of atoms, L, the latent heat of fusion and k, a constant depending upon the nature of the lattice.

The formula gives values in comparative agreement with those observed.

35. The melting points of mixtures of boric acid and hydroxylic substances.

S. M. Mehta *and* (Miss) K. V. Kantak, Bombay.

Boric acid was heated with mannitol, erythritol, glucose, galactose, tartaric acid and other hydroxylic substances until a clear melt was obtained. It was then sucked in a capillary tube where it was allowed to solidify. The melting point was determined according to the method of Christomanos (*Ber.*, 1890, **23**, 1093). The amounts of boric acid and the hydroxylic substances were determined in a weighed portion of the melted

mass. When the melting points are plotted against the ratio boric acid : hydroxylic substance, curves are obtained which show that mannitol forms definite compounds with boric acid but that the other substances give melting point diagrams with eutectics which in certain cases are as low as 60°–70°C.

36. A rapid and accurate method of measuring the porosity of insulating materials.

B. S. Srikantan, Waltair.

Insulating substances baked at different temperatures have different degrees of porosity. A quick and accurate method by the use of immersion pyknometer (*J.I.C.S.*, 1936, **13**, 136) is described, in which by measuring the specific gravity and apparent density of these substances in a powered form, the percentage of porous volume has been calculated.

37. Miscibility of alcohol and petrol.

S. R. Bhate *and* Habib Hasan, Hyderabad.

The rapid increase in the production of molasses during the recent years is causing concern to sugar-producers. In most countries it is fermented and then used as motor fuel singly or in admixture with other suitable substances. The same suggestion is made in this paper and the strengths of alcohol which will freely mix with petrol have been worked out.

38. Viscosity of binary mixtures.

P. B. Ganguly *and* S. K. Chakraverty, Patna.

A relationship between viscosity of binary liquid mixtures and molecular association has been worked out. The expression has been tested in the case of the following systems: methyl alcohol, phenetole, acetic acid, acetone, linalool. phenol, benzyl alcohol, nitrobenzene, dissolved separately in benzene. In the majority of the cases studied the expression has been found to be applicable. The result has been discussed in the light of Hildebrand's idea of association (*J. Amer. Chem. Soc.*, 1916, **38**, 1462).

39. Variation of surface tension with change in concentration of iodic acid solution.

M. R. Nayar *and* A. B. Sen, Lucknow.

Surface tension values of the solute calculated from the mixture law equation give curves corresponding to the viscosity curves with the difference that the points of intersection become points of minima and the convex portions of the viscosity curve become concave here. The points of intersection are 0·04N and 0·1N. Parachor values are being calculated.

40. Kinetics of reactions in heterogeneous systems. Part III. Hydrolysis of esters.

D. D. Karve *and* V. L. Mehendale, Poona.

The velocity of hydrolysis of (*a*) benzyl acetate and (*b*) benzyl propionate with dilute solutions of hydrochloric acid have been studied at room temperature, the ester being dissolved in xylene. The effect on the velocity of hydrolysis of changes in the concentrations of the hydrochloric acid and of the ester respectively, of increase in the quantities of the acid used and of the addition of a neutral salt have been studied.

41. Kinetics of reactions in heterogeneous systems. Part IV. Velocity of hydrolysis of some aromatic acid halides.

D. D. KARVE *and* K. K. DOLE, Poona.

The velocities of hydrolysis by water of benzoyl chloride, cinnamyl chloride and of benzoyl bromide dissolved in monochlorbenzene were studied under varying conditions of concentration of the reaching substances. The velocity constants calculated according to the monomolecular formula have given fairly constant values.

42. Kinetics of the reaction between chloral hydrate and sodium hydroxide.

A. N. KAPPANNA, Nagpur.

A detailed study of the kinetics of the reaction has been made. The bimolecular velocity constant varies with the initial concentrations of the reactants. A mechanism for the reaction, to account for the observed results, has been suggested.

43. Kinetics of heterogeneous organic reactions: A study of the benzoin reaction.

B. F. FERREIRA *and* T. S. WHEELER, Bombay.

In the study of the kinetics of the benzoin reaction at 80° the curves obtained with 1, 2 and 3 gms. of potassium cyanide are similar to those obtained at 100°C (Parts I and II, *J. Phys. Chem.*, 1935, **39**, 727) but the reaction is much slower at the lower temperature. The reaction is also being studied at 70° and 90°. Owing to the sensitiveness of the reaction to inhibitors difficulty has been experienced in obtaining consistent results at the lower temperatures.

It has been confirmed by means of long period adsorption experiments with small quantities of potassium cyanide that the benzaldehyde hitherto used in all the experiments was of a standard degree of purity (cf. Part V, *Proc. Ind. Acad. Sci.*, 1935, **2**, 605).

44. A study on the velocity of hydrolysis of some aromatic nitriles.

D. D. KARVE *and* D. V. GHARPURE, Poona.

Benzonitrile, *o*- and *p*-tolunitriles and benzyl cyanide were hydrolysed by known strengths of sulphuric acid using glacial acetic acid as solvent. The quantities of amido and ammonium salts formed were estimated separately and the total quantity of cyanide hydrolysed was calculated. The effect on the velocity of hydrolysis of the concentration of the sulphuric acid is being studied. It is also seen that owing to steric hindrance, *o*-tolunitrile remains practically unhydrolysed after 2·5 hours at 100° with 16·34N sulphuric acid.

45. Influence of temperature and of foreign electrolytes on the partition co-efficient of iodine between toluene and water.

S. S. JOSHI *and* R. R. GOREY, Benares.

The above constant has been measured in the temperature range 10–40°C and in the presence of different amounts of KI, KCl, NaCl and LiCl. Definite evidence is obtained from these data for the occurrence of polyhalides with the above named constituents under these conditions.

From a knowledge of the shift of the mass law co-efficients characteristic of these complexes, approximate estimates have been made of the corresponding heats of formation.

46. System : Sulphuric acid—ethers.

S. K. K. JATKAR *and* N. G. GAJENDRAGAD, Bangalore.

Sulphuric acid can be used to absorb the vapours of methyl and ethyl ether and the ether subsequently recovered by adding water and distilling. It is very important to know in what form the ether is absorbed and how much of it can be theoretically recovered. A continuation of the previous study of the viscosity and conductivity of the mixtures of ether with sulphuric acid has shown that although the additive compounds $H_2SO_4.C_2H_5O$ and $H_2SO_4.2(C_2H_5)_2O$ are formed (which can give up ether on addition of water) mixtures of pure sulphuric acid and small quantities of ether, give rise to further chemical reactions resulting in the formation of water. This fact alone explains quantitatively the maxima in the conductivity-composition curve and the displacement of the maxima from that required for the two above additive compounds, in the viscosity-composition curve. A limit is therefore set to the amount of ether recoverable by this process. This study has been extended to the systems sulphuric acid—methyl ether and sulphuric acid—propyl ether.

47. Equilibrium in the system $K_2CrO_4-K_2SO_4-H_2O$.

S. GOPALA RAO *and* K. R. KRISHNASWAMI.

The various solubility determinations and the compositions of the equilibrium mixtures relating to the above system at different temperatures were carried out in a thermostat by a method described in detail in the paper.

The tables given in the paper show the results obtained.

48. Valve potentiometer.

S. K. K. JATKAR, Bangalore.

This paper describes the various valve circuits used in the potentiometric investigations in our laboratory: (1) one electrometer triode followed by one stage D.C. amplifier using LP_2, a Unipivot galvanometer serving as the indicating instrument, (2) two electrometer triodes in push pull using a mirror galvanometer as a null instrument, (3) one electrometer valve followed by two stages of resistance capacity coupled amplifier, using a ballistic galvanometer as a null instrument, and (4) two P_2 valves in push pull for use both as a voltmeter for measuring pH and for differential electrometric titration, a unipivot galvanometer being the indicating instrument. The grid current is reduced to less than 10^{-11} amp.

49. Automatic potentiometric titration.

S. K. K. JATKAR *and* C. T. ABICHANDANI, Bangalore.

In view of the long time taken in electrometric titrations we have developed a simple apparatus for automatically recording the titration curve of both E and dE/dc against c.c. The reagent is added by the continuous movement of a cylindrical graduated plunger, released by the recording drum which is moving at a controlled speed. The electrodes are connected to a push pull vacuum tube circuit having a mirror galvanometer between the two anodes. The movement of the spot of light was either hand-recorded on a Cambridge Curve Tracer or photographed on a bromide paper.

50. Electrode potential of tungsten, tantalum, platinum, nickel, antimony, silver and silver chloride electrodes.

C. T. ABICHANDANI *and* S. K. K. JATKAR, Bangalore.

In the course of our experiments on the suitability of a bimetallic electrode systems for the electrometric titration of acids and bases, we studied various electrodes such as W, Ta, Pt, Ni, Sb, Ag and Ag-AgCl in buffers of different pH values.

Antimony behaves abnormally after 8 pH while tungsten behaves very well up to 10 pH. It is further observed that Ag-W, Pt-W, Ag-Sb and Pt-Sb are good pairs for the electrometric titration of acids and bases.

The tungsten electrode was used by us for the differential titration of acids and bases and it gave very sharp end points. The electrode was a wire of tungsten 1 mm. thick. We polished the electrode with sand paper at the commencement of each operation and found that the polished electrode behaved more like a hydrogen electrode than the tarnished or oxidised electrode. This behaviour is similar to that of antimony electrode.

Further the E.M.F. of the cell W (polished)/solution/H_2 was found to be almost constant at different pH values, showing that the polished electrode behaves more like a hydrogen electrode. The temperature co-efficient of the above electrode system was found to be ·003 volt.

51. Potentiometric titration of aromatic bases.

C. T. ABICHANDANI *and* S. K. K. JATKAR, Bangalore.

The differential titration of aromatic bases such as pyridine, α-picoline, β-picoline, quinoline, quinaldine and *iso*quinoline by hydrochloric acid was carried out using polished tungsten wires as electrodes.

The double peaks obtained for the end points are in favour of the idea of the existence of Kekule isomers of some of these compounds.

52. Electrolysis of aqueous calcium chloride. Part I.

S. S. JOSHI *and* S. P. SARKAR, Benares.

This has been studied in respect of the influence of (*a*) temperature, (*b*) nature of the electrode materials, (*c*) current density, (*d*) composition of the liquor at different stages of the electrolysis, and (*e*) initial addition of free HCl, K_2CrO_4 and other materials. Conditions have been studied for the non-ignition of calcium liberated at the cathode and its isolation by use of metallic mercury under special conditions. The electrolysis increases very appreciably the proportion of available chlorine, chiefly through the hypochlorite formation. The concentration of the product reaches a steady value after a certain period, whereafter, that of the chlorate begins to rise except when the temperature is too low. The addition of but small amounts of K_2CrO_4 has been found to have marked influence in increasing the yield of the hypochlorite.

53. Transport number of the silver ion in the presence of methyl alcohol.

S. S. JOSHI, A. J. HARI RAO, *and* K. RAMADAS, Benares.

It has been observed that the transport number of the silver ion increases to a maximum as the proportion of methyl alcohol in the mixture is increased, and then diminishes for further increase of methyl alcohol. Determinations of the viscosity of the medium at different percentages of methyl alcohol gave curves strikingly similar to those obtained in respect of the transport numbers. These results are discussed on the possible variations of the significant ionic mobilities, formation of com-

plexes between the two components, hydration of the ions and other possible determinants of the transport number, on the basis of the theories developed by Kruger (*Z. Elektrochem.*, 1916, **22**, 445), Krumarisch (*ibid.*) and others.

54. Aqueous solutions of sodium aluminate.

S. M. MEHTA *and* (MISS) OLIVE JOSEPH, Bombay.

Solutions containing different proportions of sodium hydroxide and aluminium hydroxide expressed as the ratios of Na_2O : Al_2O_3 have been investigated in the same manner as those of sodium zincate reported before (*Proc. Ind. Sci. Cong.*, 1835, p. 113) by one of the authors. The electrical conductivity has been measured between 2N and 0·01N. Crystals of definite aluminates have been isolated from the solutions containing hydroxide dissolved in more than 10N sodium hydroxide as well as from those in 2N and 5N sodium hydroxide. Further work on the determination of the hydrogen ion concentration by means of the glass electrode is in progress.

55. Electro-typing.

V. MANIYAN, Bangalore.

The suitability of different wax mixtures for getting accurate impressions from old coins and of different preparations of graphite for coating the impressions prior to electrotyping, has been investigated.

56. The evaluations of Λ_0 and of K for soaps in alcohol-water mixtures.

S. K. K. JATKAR *and* B. S. V. K. VITTAL, Bangalore.

In continuation of our previous study of the conductivity of pure soaps in ethyl alcohol and ethyl alcohol-water mixtures, we have now calculated Λ_0 the limiting conductance, and K the dissociation constant by the method of Fuoss and Kraus, for all the mixtures except 87 per cent. alcohol which is anomalous because the conductance decreases with dilution in the same range in which there is an increase in the case of other mixtures.

57. The influence of magnetic field on adsorption.

S. S. BHATNAGAR, P. L. KAPUR, *and* A. N. KAPUR, Lahore.

Effect of magnetic field on the adsorption of $KMnO_4$, $K_2Cr_2O_7$, $K_4Fe(CN)_6$ and $FeCl_3$ by charcoal and of $KMnO_4$ and $K_4Fe(CN)_6$ by $BaSO_4$ has been studied. In the system $KMnO_4$-charcoal $K_2Cr_2O_7$-charcoal adsorption is increased; in $FeCl_3$-charcoal it is decreased; whereas in $KMnO_4$-$BaSO_4$, $K_4Fe(CN)_6$-$BaSO_4$ it is not influenced by magnetic field.

Thus we find that magnetic field influences adsorption as it does various other chemical reactions according to rules deduced by Bhatnagar, Mathur and Kapur (*Phil. Mag.*, 1929, 8, 457).

58. Particle size and magnetic susceptibility.

S. S. BHATNAGAR, M. R. VERMA, *and* M. ANWAR-UL-HAQ, Lahore.

The mass magnetic susceptibility of lead, copper, bismuth, antimony, sulphur, selenium and tellurium has been measured at particle size of the order 0·4μ and has been found in each case to be the same as that of the

corresponding metal *en masse*, provided impurities like oxides, hydroxides, carbonates, etc. are suitably removed. Evidence in favour of this point has also been brought forth by agglomerating the purified powder of lead, bismuth and antimony, when no change in the susceptibility value is observed, which it should have been if there were any particle size effect.

It is pointed out that Rao's conclusions (*Current Science*, 1936, **4**, 572) on copper, bismuth and antimony are not correct because he has presumably neglected the influence of carbon inclusion in the case of the former metal and that due to the formation of oxides and hydroxides in the case of the last two metals. Further, his inference from the work of Prins that antimony is amorphous in the colloidal state is not borne out from the original text of Prins.

59. Magneto-optical rotation of liquid mixtures.

S. S. BHATNAGAR, M. R. VERMA, *and* P. C. KHANNA, Lahore.

Magneto-optical rotation of the following pairs of liquids was measured at various molar concentrations :—

(1) Xylene—aniline, (2) Toluene—aniline, (3) Xylene—nitrobenzene, (4) Xylene—*o*-nitrotoluene, (5) Toluene—nitrobenzene, (6) Nitrobenzene—aniline, (7) Aniline—*m*-cresol, (8) *o*-Nitrotoluene—*m*-cresol, (9) Nitrobenzene—*m*-cresol, (10) Water in phenol—phenol, (11) Phenol in water—water.

Deviation in rotation from the addivity value is obtained only in those mixtures which show a departure in density from the linear law. The results are discussed in view of the possibility of dipolar association and chemical combination.

60. A magnetic study of colour changes in cobalt chloride.

S. S. BHATNAGAR, A. N. KAPUR, *and* P. L. KAPUR, Lahore.

Magneto-optic rotations of $CoCl_2 \cdot 6H_2O$ solutions in different solvents have been studied. The colour and molecular magnetic rotation of cobaltous chloride solutions in amyl alcohol and hydrochloric acid change considerably with concentration while in aqueous solutions the change is only just noticeable. The colour change is brought about both by changing the state of ionization and by causing dehydration, but the predominant factor is the formation of complex ions of the type $(CoCl_3)'$ and $(CoCl_4)''$ as already suggested by Bhatnagar and Kapur (*J. Indian Chem. Soc.*, 1932, **9**, 341).

61. Decolourising action of Fuller's earth.

B. S. KULKARNI *and* S. K. K. JATKAR, Bangalore.

In the course of the work on the activation of Fuller's earths obtained from different parts of India, it was observed that the pH of the solution of sodium chloride treated with the earths varied in the same manner as the change in the units of colour removed. It has been found that the decolourising action and the activation of these earths by acids are directly related to the exchangeable hydrogen ions contained in the earths. Thus the cation of the Fuller's earth which is of zeolitic nature is replaced by the hydrogen ion during the process of activation by acids, the hydrogen in turn being replaced by sodium ion when treated with the salt solution, both reactions being governed by law of mass action. This paper reports the results obtained regarding the value of the equilibrium constant involved for the different earths studied.

62. Effect of ultra-violet light on chromium hydroxide sols of a high degree of purity.

D. S. DATAR *and* M. QURESHI, Hyderabad (Deccan).

Chromium-hydroxide sols were prepared by three different methods and purified by the process of continuous dialysis extending over 60 hours and more. The progress of dialysis was followed up by the measurement of light-absorption, pH value and electrical conductivity. The extinction co-efficient curves of the dialysed sols have the same form and the same regions of maximum and minimum absorption namely 5900 and 5150Å, respectively, although the intensity of absorption in each case is different.

Exposure for 24 hours to ultra-violet light of a sol dialysed for 60 hours, results in an increase in the light-absorption as well as in the chromium-chlorine ratio. The pH value shows at first a decrease, followed by an increase on long exposures. Similarly electrical conductivity first decreases and then increases. An explanation has been offered for this behaviour. The effect of dilution and ageing on the abovementioned properties has also been investigated.

63. On the relation between peptisation of a precipitate and its electrokinetic potential and the electric charge of a precipitate formed in presence of an excess of one of the constituent ions.

S. G. CHAUDHURY *and* J. SEN GUPTA, Calcutta.

During the course of peptization of a precipitate, a rise of the electric charge of the particles of the precipitate always occurs. The precipitates studied are copper ferrocyanide, uranium ferrocyanide, zinc ferrocyanide and silver iodide. A polar precipitate does not always show a positive charge in presence of an excess of an electrolyte having a constituent positive ion, nor does it always show a negative charge in excess of an electrolyte having a constituent negative ion.

The charge of a polar precipitate in excess of either one or other electrolytes taken for precipitation depends : (*a*) on the initial concentrations of the precipitants taken, and (*b*) on the time after which measurements of charge were taken, i.e., on the age of the precipitate. These observations go against all the theories hitherto proposed to explain the nature of the charge of a polar precipitate in presence of an excess of either of the common ions.

The work was undertaken under the guidance of Prof. J. N. Mukherjee.

64. Colloidal structure and infra-red absorption spectra.

S. S. BHATNAGAR, P. L. KAPUR, *and* M. D. RAJPAL, Lahore.

Infra-red absorption spectra of Fe_2O_3, As_2S_3, SiO_2, SnO_2 and Au hydrosols prepared by different methods has been studied between 0·8 μ and 2·0 μ. Almost all the sols have been found to be less transparent than water in the region of 0·9 μ to 1·3 μ and 1·55 μ to 1·75 μ and are more transparent in the region 1·3 μ to 1·55 μ and beyond 1·75 μ. There is a striking similarity between their percentage transmission curves particularly in respect of the absorption bands occurring at 1·0 μ, 1·2 μ and 1·6 μ. The change in transparency of water and the shifts in the position of water bands has been attributed to the disturbance of equilibrium between the mono-, di- and trihydrol molecules of water caused by the hydrated colloidal particles. The SiO_2 and SnO_2 sols have been shown to have maxima of the absorption bands at 1·26 μ, 1·9 μ and 1·06 μ respectively besides those of the other sols. This difference in two sets

of sols is due to their difference in nature, i.e., their hydrophobic and hydrophilic character.

65. 'Zonal effect' in the variation of the opacity during the coagulations of colloid manganese dioxide.

S. S. JOSHI *and* P. V. JAGANNATHA RAO, Benares.

That coagulation leads necessarily to an increase of the turbidity or opacity of the coagulating system has been assumed tacitly by colloid chemists. This underlies the numerous investigations on the kinetics of the above process from an experimental standpoint, in the light of the current theories developed chiefly by Smoluchowski (*Z. physikal. Chem.*, 1917, **92**, 129), Freundlich (Colloid and Capillary Chemistry, 1926, pp. 442) and others. As is to be anticipated from the simple and restricted mechanism of the process contemplated in the above theories, disparity exists appreciably between the requirements of the theory and actual practice, especially in the slow region of the reaction. Based on the results of work from these laboratories, it was suggested that the change is essentially discontinuous as revealed in the time variation by some of the principal properties which are employed usually by following the progress of coagulation. No information in this line is available in the literature in respect of the opacity as a measure of the change. With the exception of two preliminary communications (Joshi and Jaya Rao, *J. Indian Chem. Soc.*, 1936, **13**, 311; Joshi and Purushottam, *Current Science*, 1936, **4**, 870), it does not appear to have been noted that even this property, which has had perhaps longest and widest usage as a measure of coagulation, shows a 'zonal effect' in the slow region. More detailed studies have shown in the case of colloidal manganese dioxide using differently concentrated solutions of KCl, $BaCl_2$ and CH_3COOH as coagulants that, contrary to usual experience, the opacity actually diminishes after the familiar rise in the initial stages. Under certain conditions the opacity diminishes first and then rises. Interesting results were obtained when monochromatic light was used for the opacity measurements. Under all these conditions, it was found that the change of opacity was always zonal irrespective of whether this property changed normally or otherwise during the occurrence of the change.

66. 'Zonal effect' in the coagulation of gold hydrosol.

S. S. JOSHI *and* N. HANUMANTHA RAO, Benares.

In previous communications from these laboratories (Joshi and Viswanath, *J. Indian Chem. Soc.*, 1933, **10**, 329; Joshi and Menon, *ibid.* 1933, **10**, 599; Joshi and Nanjappa, *ibid.*, 1934, **11**, 133; Joshi and Iyengar, *ibid.* 1934, **11**, 555; 573; 577; Joshi and Pannikar, *ibid.* 1934, **11**, 797, 804; 1936, **13**, 309; *Proc. Acad. Sci. U.P.*, 1935, **5**, 41; *J. Chim. Phys.*, 1935, **32**, 455; Joshi and Sarkar, *J. Bombay Univ.*, 1935, **4**, 140; Joshi and S. Jaya Rao, *J. Indian Chem. Soc.*, 1936, **13**, 141; 311; *Koll. Zeit.* 1936, **76**, 146), it has been shown that the process of slow coagulation of a number of sols produced by variously concentrated solutions of different electrolytes, and by oppositely charged sols is not continuous with respect to the coagulation time. Since this conclusion constitutes a departure from the current theories of the kinetics of coagulation, it was of interest to follow the coagulation of gold hydrosol, for which very detailed data are available in the literature.

In the present work, two independent methods were employed to follow the process of coagulation, viz. change of the viscosity and of refractive index. These experiments show that coagulation is not time-continuous and that this feature becomes more pronounced the slower the change. Results also show, contrary to the tacit assumption made generally by colloid chemists, that coagulation does not necessarily produce a net increase of viscosity. Moreover, contrary to the finding

of Galecki (*Koll. Zeit.*, 1925, **36**, 154, et. seq.) the characteristic changes, viz., red to violet, is not confined to the occurrence of the first minimum on the viscosity—time curves. The discontinuities termed the 'Zones of coagulation' are brought out vividly by the refractivity—time curves which have been studied in detail. The 'zones' tend to disappear during both rapid and very slow coagulations.

67. The coagulation of colloid antimony sulphide by aqueous mercury chloride.

S. S. JOSHI *and* T. MADHAVA MENON, Benares.

It was shown in a recent publication (Joshi and Kulkarni, *J. Indian Chem. Soc.*, 1936, **13**, 439) that in by far the majority of cases coagulations of colloid arsenious sulphide produced no sensible variations in the viscosity, transparency and opacity (determined by independent means) of the colloid when coagulated by mercury chloride. The normal variations in these properties occurred under the above conditions if other electrolytes were used as coagulants both when (1) used alone, and (ii) when but small amounts of these were mixed with $HgCl_2$ used for producing coagulation. These measurements have now been extended to the study of the coagulation of colloid Sb_2S_3 by $HgCl_2$. It was found that the character of the variation of any of the above properties depended chiefly upon the coagulator concentration. For low values of the latter, results were similar to those obtained in the case of colloid As_2S_3 and $HgCl_2$, in respect of all the three properties mentioned above, i.e., they remained sensibly stationary although visible flocculation had occurred in the system. In rapid coagulations all the properties showed the familiar type of variation. In intermediate regions, all the properties showed discontinuous variations. This last conclusion was also confirmed by a detailed study of the change of refractive index during coagulation. It is concluded, therefore, that the *ad hoc* utilization of any of these four properties as a measure of the corresponding degree of coagulation is subject to an inherent uncertainty. It is certainly unreliable as a general measure of coagulation.

68. Viscosity of thorium molybdate gels during formation.

MATA PRASAD *and* (MISS) RATHNAMA, Bombay.

The viscosity of thorium molybdate gels prepared by mixing solutions of thorium nitrate and potassium molybdate has been measured at different intervals during its formation. The effect of the variation of concentrations of thorium nitrate and of potassium molybdate and of the addition of electrolytes and non-electrolytes on the viscosity of the gel-forming mixtures has also been examined. The viscosity—time curves are irregular. The thiotropy of these gels is discussed in view of these observations. All the gels used in this investigation were transparent or translucent.

69. Swelling of gels. Part II.

N. A. YAJNIK *and* M. AHZAL KHAN, Lahore.

The swelling of blue and agar-agar gels in water has been studied at various pH's and in presence of different electrolytes. It has been observed that:

1. In case of glue gels the swelling was minimum at pH 5, while in agar-agar gels the maximum imbibition was obtained at pH 7.
2. On comparing the influence of the electrolytes with common anions, it was observed that the swelling of glue gels went on decreasing with the increase of molecular weight, whilst reverse was the case of agar-agar gels.

70. Studies in barium malonate gels.

MATA PRASAD *and* KARTAR NARAIN, Bombay.

The setting of barium malonate gels has been studied at different temperatures using solutions of different concentrations of the malonic acid. It has been found that with an increase in the concentration of the acid the time of setting first decreases, reaches a minimum, then increases and reaches a maximum and again decreases until at high concentrations the time—concentration curve runs almost parallel to the concentration axis. The increase of temperature also shows that the time of setting first increases, reaches a maximum value and then decreases.

71. Studies in inorganic gels.

MATA PRASAD *and* D. M. DESAI, Bombay.

A number of inorganic gels, some already known, have been obtained in a transparent condition by properly controlling the hydrogen-ion concentration of the gel forming mixtures. In each case the limits of concentration of the gel-forming solutions have been determined and the effect of temperature and of the addition of non-electrolytes on the formation of gels has been examined. The heat of activation of the gels has been calculated from Arrhenius' equation.

72. Adsorptive properties of synthetic resins.

S. S. BHATNAGAR, A. N. KAPUR, *and* M. L. PURI, Lahore.

Adsorptive properties of synthetic resins have been studied in detail and the authors find that the taking up of dissolved substances from solution by the adsorbent resins follows the ordinary laws of adsorption and is mainly a surface phenomenon. The adsorption from aqueous solutions of benzoic, salicylic, anthranilic, picric, formic, acetic, propionic, butyric, amino-acetic, lactic, sulphuric, nitric, hydrochloric acids has been studied. Aromatic acids are adsorbed to a greater extent than aliphatic acids. In a homologous series, the adsorption of organic substances from aqueous solutions increases strongly and regularly as we ascend the series. Inorganic acids are preferentially adsorbed in the order $H_2SO_4 > HNO_3 > HCl$. The adsorption from solutions other than aqueous was also studied and the use of difference in degree of sorption from solvents in the recovery of various substances from solutions has been investigated. These resins can be economically prepared as commercial adsorbents and have advantage over charcoal and silica in that, whereas charcoal does not adsorb inorganic bases and silica inorganic acids, the resins adsorb both types of substances fairly strongly.

73. Adsorption by precipitates.

N. A. YAJNIK, P. L. KAPUR, *and* R. L. MALHOTRA, Lahore.

Adsorption of various negative ions namely oxalate, ferro-cyanide, iodate, chromate, nitrate, cyanide, chloride, permanganate, bromate and sulphocyanide by iron, aluminium, chromium and manganese hydroxides has been studied. The hydroxides, precipitated at the ordinary temperature from corresponding 2N-chloride solutions by dilute ammonia, were washed by decantation and dialysed till free from chloride. Known weight of the hydroxide was always taken and the conditions for adsorption of different ions were kept the same. The order of the ions adsorbed is :

oxalate > ferrocyanide > iodate > nitrate > chromate > cyanide > chloride > permanganate > bromate > sulphocyanide.

Organic Chemistry

74. Dehydrogenation of methanol.

N. V. KAREKAR *and* S. K. K. JATKAR, Bangalore.

We have measured the comparative activity of different catalysts like copper, brass, silver plated copper guage and calcium silicate-vanadate, for dehydrogenating methanol to yield formaldehyde. The last named catalyst was found to be the best.

75. Constitutions of 'Urea' from chemical reactions and physico-chemical studies.

P. B. SARKAR, B. C. RAY, *and* J. GUPTA, Calcutta.

Although the literature on the subject seems exhaustive, and various views have been put forward—*singly* none of them appears to be satisfactory. The '*chemical*' constitution, may or may not be identical with the '*true*' constitution of a compound. They are identical, however, only where mobility and reversibility are exceptional. The problem of this nature cannot be solved by examining the behaviour in solution. Examination of the solid is essential. Physico-chemical methods have been applied to arrive at a reconciliation of the various facts hitherto observed.

76. Studies in geometrical isomerism. Part IV. The action of organic bases on α-bromo-lignoceric acid and its methyl ester.

P. RAMASWAMI AYYAR, Bangalore.

The action of dimethylaniline on the bromo-acid yields the expected $\Delta^{2:3}$-unsaturated acid, the geometrical isomerism of which is under investigation. But the action of pyridine on the methyl ester gives a yellow condensation product (m.p. 185°d) which is under investigation.

77. Studies in geometrical isomerism. Part V. The action of diethylaniline on α-bromo-stearic acid and its methyl ester.

(MISS) P. DEVI *and* P. RAMASWAMI AYYAR, Bangalore.

The remarkable observation has been made that stearic acid is a product of the above reaction, in addition to the expected $\Delta^{2:3}$-oleic acid, the geometrical isomerides of which are being investigated.

78. Studies in geometrical isomerism. Part VI. The action of bases on α-bromo-eicosanic acid.

(MISS) P. DEVI *and* P. RAMASWAMI AYYAR, Bangalore.

The action of methyl alcoholic and ethyl alcoholic potash on the bromo-acid yields only α-hydroxy-eicosanic acid, and not the expected $\Delta^{2:3}$-eicosenoic acid. The action of diethylaniline on the bromo-acid and its methyl ester is being studied.

79. The condensation of aldehydes with malonic acid in the presence of organic bases. Part VIII. The condensation of methoxy-salicylaldehyde.

K. C. PANDYA *and* T. A. VAHIDY, Agra.

Methoxy-salicylaldehyde was condensed in the usual way, by the method of Kurien and Pandya (*J. Indian Chem. Soc.*, 1925, *11*, 825) and Pandya and Vahidy (*Proc. Ind. Acad. Sci.*, 1935, *2*, 402), with malonic acid in the presence of a trace of pyridine, piperidine, lutidine, etc. Quantitative yields of *o*-methoxycinnamic acid were obtained.

It may be noted that *m*-methoxy-benzaldehyde has similarly been condensed to give *m*-methoxycinnamic acid in 90 per cent. yield by the same method by Robinson and Walker (*J.*, 1936, 193).

80. Quantitative determination of aromatic amines. (Application of the potentiometric method to diazotization).

BALWANT SINGH, G. AHMAD, *and* H. B. DUNNICLIFF, Lahore.

o-Nitroaniline, *m*-nitroaniline, *p*-nitroaniline, *o*-aminobenzoic acid, *p*-aminobenzoic acid, sulphanilic acid, *p*-chloroaniline, 3-nitro-4-amino-phenetole and 2-amino-4-nitrophenol have been determined quantitatively by titrating them against a standard solution of sodium nitrite in presence of hydrochloric acid by the potentiometric method.

81. Reactivity of piperonyl halides.

R. G. NAIK *and* T. S. WHEELER, Bombay.

The authors have studied the reactivity of the side-chain halogen atom in various piperonyl halides. The halogen atom in the side-chain is easily replaced when refluxed with alcohols in presence of sodium carbonate giving the corresponding ethers. If the alkali be not present, polymerization occurs.

The halogen atom in the side-chain is easily replaced by the cyano-group, when refluxed with alcoholic potassium cyanide for several hours. The nitriles on hydrolysis with alkali readily yield the corresponding phenyl-acetic acids. This new method of synthesising phenyl-acetic acids appears to be of interest.

82. Imido-chlorides: Condensation of N-methylurethane with benzanilideimidochloride.

R. C. SHAH *and* H. P. GHADIALI, Bombay.

In view of the interesting results obtained with N-phenylurethane (*Indian Sci. Cong. Abst.*, 1936, 101), the investigation has been extended to N-methylurethane. The crystalline condensation product phenyl-iminobenzyl-methyl-urethane is readily hydrolysed by boiling dilute hydrochloric acid to benzanilide, and forms a stable dibromo additive product. Phenyliminobenzyl-methylurethane, like the corresponding N-phenyl compound, does not undergo cyclization to a quinazoline derivative; the N-methyl group, like the N-phenyl group therefore inhibits ring-closure. The action of alcoholic potash led to phenylmethyl-benzamidine. The action of α-naphthylamine gave a urea derivative, and reduction by aluminium amalgam in moist ether afforded the dihydro-compound which is readily hydrolysed to benzaldehyde.

83. Studies in the chemistry of amidines : Diamidines.

H. K. S. RAO *and* T. S. WHEELER, Bombay.

Dibenzoyl benzidine and PCl_5 react in the presence of nitrobenzene to give the corresponding di-imidochloride. This has been condensed with aryl amines and ammonia to give di-amidines all of which are new. The imidochloride has been condensed so far with monomethyl-aniline, mono-ethylaniline, ethyl-*p*-toluidine, ethyl-*o*-toluidine, methyl-*o*-toluidine, benzylaniline, *o*-chloraniline, *o*-anisidine, *o*-toluidine and ammonia. All these amidines which are yellow crystalline solids with very high melting points, have been converted into picrates.

The imidochloride resulting from the reaction of PCl_5 on dibenzoyl-*p*-phenylenediamine in the presence of nitrobenzene, has been condensed with aryl amines to give the corresponding di-amidines. The amines so far used are methylaniline, methyl-*o*-toluidine and benzylaniline The amidines are being converted into picrates and hydrochlorides.

It is hoped eventually to study the tautomerism of the di-amidines.

84. Geometrical isomerism in amidines.

R. C. SHAH *and* M. M. SIDIKI, Bombay.

The isomerism of the two pairs of amidines obtained from benzanilideimidochloride by the action of: (i) monomethylaniline and dimethylaniline, and (ii) monoethylaniline and diethylaniline (*J.*, 1932, 649) has been further studied. The constitutions of the amidines as N-alkyl diphenylbenzamidines—(*a*) N-methyl, (*b*) N-ethyl—have been established by hydrolysis with conc. hydrochloric acid in a sealed tube at a high temperature, and also confirmed by molecular weight determinations. The isomerism is, therefore, most probably geometrical isomerism. This observation is of interest as geometrical isomerism has not been hitherto encountered in the amidine series.

85. Condensation of β-aryl glutaconic acids with phenolic ethers.

G. R. GOGTE, Bangalore.

The constitution viz. ββ-(4 : 4′-dimethoxy-diphenyl)-glutaric acid assigned to the product of condensation of β-(4-methoxyphenyl)-glutaconic acid with anisole reported last year (*Proc. Ind. Sci. Cong.*, 1936, 24) has been proved conclusively by the formation of the well known αα-(4 : 4′-dimethoxy-diphenyl)-ethylene from the latter on treatment with lime.

The β-(4-ethoxyphenyl)-glutaconic acid, the β-(4-methoxy-3-methyl)-glutaconic acid and the β-(4-ethoxy-3-methyl)-glutaconic acid, condensed in a similar manner with phenetole, *o*-cresol-methyl and ethyl ethers respectively to give the corresponding ββ-diaryl glutaric acids of the para-series. These latter also produced the corresponding αα-diaryl ethylenes by lime treatment.

86. Halogenation. Part XX. Halogenation of fluorene.

P. S. VARMA *and* V. SUBBA RAO, Benares.

From the study of the literature it seems that only one iodo-derivative of fluorene has been obtained before and no mixed halogen derivatives are known. It has been possible to prepare a second derivative of fluorene, 2 : 7-di-iodofluorene, by three different methods; the one from 2 : 7-dinitrofluorene by reduction and diazotization, the second from 2-iodo-fluorene by nitration, reduction and subsequent diazotization and the third from fluorene itself by direct iodination in presence of strong nitric and fuming

sulphuric acids. All the three methods yield the same di-iodo-derivative. A number of new mixed halogen derivatives such as bromo-iodo-fluorene, chloro-bromo-fluorene, bromo-iodo-fluorene etc. have also been prepared.

87. Halogenation. Part XXI. Bromination and iodination of triphenylmethane.

P. S. VARMA *and* V. RAMA IYER, Benares.

The study of the literature shows that little work has been done on the direct bromination and iodination of triphenylmethane. Most of the bromo- and iodo-derivatives have been obtained by indirect methods only. Triphenylmethane has been brominated by the authors under different conditions in the cold or on a water bath in presence of substances such as (I) concentrated nitric acid, (II) fuming nitric acid, (III) concentrated sulphuric acid, (IV) fuming sulphuric acid, (V) a mixture of strong nitric and sulphuric acids, (VI) a mixture of fuming nitric and fuming sulphuric acids, and (VII) sodium nitrite and fuming sulphuric acid and a number of bromo-derivatives obtained. The conditions for getting the maximum yield of these compounds have also been studied. Similar experiments have also been conducted on the direct iodination of triphenylmethane.

88. Halogenation. Part XXII. Halogenation of methylethylaniline.

P. S. VARMA *and* P. V. ANANT RAMAN, Benares.

An exhaustive study of the chlorination, bromination and iodination of methylethylaniline has been made and a number of chloro-, bromo- and iodo-derivatives have been obtained. Some of these halogen derivatives have also been nitrated and some new nitro-halogen derivatives have been prepared.

89. Halogenation. Part XXIII. Halogenation of monomethyl-*o*-toluidine.

P. S. VARMA *and* D. B. DAS GUPTA, Benares.

Chlorination, bromination and iodination of monomethyl-*o*-toluidine have been carried out under different conditions as a result of which a number of halogen derivatives of this compound has been obtained.

90. Interaction of thionyl chloride and sulphur dichloride with salicylic acid and its esters.

J. A. KUNDARGI, Y. M. CHAKRADEO, *and* S. V. SHAH, Kohlapur.

The action of thionyl chloride on ethyl salicylate, methyl salicylate, and phenyl salicylate, and that of sulphur dichloride on the above compound as well as on salicylic acid, all in the presence of iron dust, zinc dust, and chlorides of iron, zinc, tin, antimony and bismuth, have been investigated.

Products of the type of $(C_6H_4{\cdot}OH{\cdot}COOR)_2S$ have been formed where R represents CH_3, C_2H_5 and C_6H_5. Thionyl chloride is turned into sulphur dichloride according to the following equation:

$$SOCl_2 = SCl_2 + O$$

and the resulting sulphur dichloride eliminates hydrogen chloride with a hydrogen atom from each of the benzene rings, which are linked to each other through the sulphur atom of sulphur dichloride. The thio-com-

pounds formed are identical with those obtained by Hirve, Jadhav and Chakradeo (*J. Amer. Chem. Soc.*, 1935, 101–103 ; *Jour. Univ. Bom.*, 1933, 128–31 and *J. Indian Chem. Soc.*, 1934, 551–554).

91. Synthetic pungent principles.

P. C. MITTER *and* SUDHIRCHANDRA RAY, Calcutta.

The naturally occurring pungent principles are found to possess the acylamide (-N-CO-) linking in common, the amine being either primary or secondary. It may be heterocyclic like piperidine as in piperine or fatty-aromatic like vanillylamine as in capsaicin or even purely aliphatic like *iso*butylamine as in fagaramide. The acid is either aliphatic or fatty-aromatic and contains at least one double bond. The object of this paper was to synthesise a number of *iso*butylamides, acylated with both saturated and unsaturated acids and to determine the effect of the number of carbon atoms in the chains, the distance of the double bond (if any) from the -N-CO- group, the presence or absence of a phenolic group etc. on pungency.

Altogether the amides of twelve acids have been investigated and some interesting conclusions arrived at.

92. The influence of α-phenyl group in three carbon tautomerism.

N. L. PHALANIKAR *and* K. S. NARGUND, Ahmedabad.

In continuation of previous work (*Proc. Indian Sci. Congress*, 1936, 23) the mobilities and the positions of equilibrium have been determined and are given in the following table.

Compounds.	Catalyst used.	%αβ at equilibrium.	Mobility.
α-Phenyl *cyclo*hexenyl acetic acid .. α-Phenyl *cyclo*hexylidene acetic acid.	KOH	42	$0{\cdot}0095 = 10(K_1+K_2)$
Phenyl hexenoic acid Phenyl hexenoic acid	KOH	87	$0{\cdot}50 = 10(K_1+K_2)$
Ethyl phenyl*cyclo*hexylidine acetate Ethyl phenyl*cyclo*hexenyl acetate.	C_2H_5ONa	72	$0{\cdot}99 = (K_1+K_2)10^4$
Ethyl phenylhexenoate .. Ethyl phenylhexenoate.	C_2H_5ONa	95	$35{\cdot}6 = (K_1+K_2)10^4$

The results are discussed in relation to the polar behaviour of phenyl group.

93. Synthesis of α-resorcylaldehyde and related compounds.

R. C. SHAH *and* M. C. LAIWALLA, Bombay.

Methyl β-resorcylate (I) does not undergo the Gattermann reaction under the usual conditions. It is found, however, that under special

conditions, viz. in the presence of anhydrous aluminium chloride dissolved in dry ether (*cf.* Shah, *Current Sci.*, 1934, 157) the reaction proceeds very smoothly and a high yield of the aldehyde-ester (II) is obtained. The aldehydo group is found unexpectedly to enter exclusively the usually inaccessible γ-position in the resorcinol nucleus. This welcome observation has made possible a simple synthesis of γ-resorcylaldehyde, which has been synthesised thus :

Methyl β-resorcylate→2-aldehydo-6-carbomethoxyresorcin→2-aldehydo-6-carboxyresorcinol→(decarboxylation)→resorcyl-aldehyde.

The yields are high except during decarboxylation when a 33% yield is obtained. γ-Resorcylic aldehyde has m.p. 155-156°.

γ-Resorcylaldehyde has been recently synthesised by a different method (Limaye, *Rasayanam*, 1936, No. 1, Vol. I, Page 13).

The constitution of the aldehyde-ester as methyl 2 : 4-dihydroxy-3-aldehydo-benzoate has been definitely established. The aldehyde ester on reduction gave methyl 2 : 4-dihydroxy-3-methylbenzoate, which on methylation yielded methyl 2-hydroxy-3-methyl-4-methoxybenzoate (of proved constitution) which was found to be identical by direct comparison with the compound prepared by nuclear methylation of β-resorcylic acid by Perkin's method.

A number of related compounds has been prepared from methyl 2 : 4-dihydroxy-3-aldehydo-benzoate including the hitherto unknown 2 : 4-dihydroxy-3-methylbenzoic acid and 2 : 4-dimethoxy-3-methyl benzoic acid. γ-Resorcylaldehyde on reduction gave 2-methyl-resorcinol.

94. Condensation of succinic anhydride with phenolic ethers.

G. A. Dalal *and* K. S. Nargund, Ahmedabad.

Succinic anhydride has been condensed with phenolic ethers by Friedel and Crafts' reaction using nitrobenzene as solvent. Resorcinol-dimethyl ether gave γ-keto-γ-2 : 4-dimethoxy phenyl butyric acid, m.p. 148°. Hydroquinone dimethylether gave γ-keto-γ-2 : 5-dimethoxyphenyl butyric acid, m.p. 107°. Pyrogallol trimethyl ether gave γ-keto-γ-2 : 3 : 4-trimethoxyphenyl butyric acid, m.p. 153°. Resorcinol monomethyl ether gave a product which is most likely γ-keto-γ-2-hydroxy-4-methoxyphenyl-butyric acid, m.p. 156°.

The constitutions of the above acids have been proved by oxidation. Further work on the condensation of dihydric phenols with succinic anhydride is in progress.

95 Condensation of succinic anhydride with naphthol methyl ethers.

K. P. Dave *and* K. S. Nargund, Ahmedabad.

α-Naphthol methyl ether when condensed with succinic anhydride in nitrobenzene by Friedel and Crafts' method gave-γ-keto-γ-4-methoxy-naphthyl-butyric acid, m.p. 173°. The constitution of this acid has been proved (*a*) by oxidation to 4-methoxynaphthoic acid, (*b*) by Clemmensen reduction to 4-methoxy-naphthyl-butyric acid (Kon and Ruzicca, *J.*, 1936, 192), and (*c*) by synthesis from the Grignard reagent, prepared from 4-bromo-α-naphthol methyl ether and succinic anhydride. The condensation of succinic anhydride with β-naphthol methyl ether confirms the results of Short, Stromberg and Wiles (*J.*, 1936, 320).

96. Isomeric triazocinnamic acids.

K. A. NARAIN RAO *and* P. R. VENKATARAMAN, Annamalainagar.

The isomeric *o*-, *m*- and *p*-triazocinnamic acids have been prepared from the corresponding aminocinnamic acids by diazotization and interaction with sodium azide. They do not explode when heated although they react very violently with concentrated sulphuric acid. The properties of these isomers have been investigated in detail by a study of their behaviour on oxidation, reduction and decomposition involving elimination of nitrogen.

97. Formation and transformation of carbon ring compounds. Part IV.

S. C. SENGUPTA, Calcutta.

The present communication deals with the syntheses of hydronaphthalene derivatives containing a gem-dimethyl substituent and also the effect of selenium dehydrogenation on these compounds. *unsymm*-Dimethyl succinic anhydride condensed with benzene and toluene in presence of aluminium chloride forming $\beta\beta$-dimethyl-γ-keto-γ-phenyl butyric acid (m.p. 170-171°) and $\beta\beta$-dimethyl-γ-keto-γ-(*p*-tolyl)-butyric acid (m.p. 158-159°) respectively. These two keto acids on reduction by the Clemmensen method gave $\beta\beta$-dimethyl-γ-phenyl butyric acid (m.p. 98°) and $\beta\beta$-dimethyl-γ-(*p*-tolyl)-butyric acid (m.p. 111-112°), which on cyclization with 85% sulphuric acid gave 1-keto-3 : 3-dimethyl-1 : 2 : 3 : 4-tetrahydro-naphthalene and 1-keto-3 : 3 : 7-trimethyl-1 : 2 : 3 : 4-tetrahydronaphthalene respectively. The keto cyclic compounds thus obtained on Clemmensen reduction yielded 3 : 3-dimethyl-1 : 2 : 3 : 4-tetrahydro-naphthalene and 3 : 3 : 7-trimethyl-1 : 2 : 3 : 4-tetrahydronaphthalene respectively. These two tetrahydronaphthalene derivatives containing gem-dimethyl substituents on heating with selenium at 300° could not be dehydrogenated to naphthalene or alkyl naphthalenes.

98. Formation and transformation of carbon ring compounds. Part V.

S. C. SENGUPTA, Calcutta.

In this paper *unsymm*-dimethyl succinic anhydride has been condensed with naphthalene in presence of anhydrous aluminium chloride giving $\alpha\alpha$-dimethyl-γ-keto-γ-1-naphthyl butyric acid (m.p. 190-91°) and $\alpha\alpha$-dimethyl-γ-keto-γ-2-naphthyl butyric acid (m.p. 170°). These two keto acids on reduction by the Clemmensen method gave $\alpha\alpha$-dimethyl-γ-1-naphthyl butyric acid (m.p. 99-101°) and $\alpha\alpha$-dimethyl-γ-2-naphthyl butyric acid (m.p. 133–135°) which on cyclization with 85% sulphuric acid gave 1-keto-2 : 2-dimethyl-1 : 2 : 3 : 4-tetrahydrophenanthrene (m.p. 68-69°) and 4-keto-3 : 3-dimethyl-1 : 2 : 3 : 4-tetrahydrophenanthrene (b.p. 185–187°/8 mm.) respectively. Clemmensen reduction of these two keto-phenanthrene derivatives gave 2 : 2-dimethyl-1 : 2 : 3 : 4 tetrahydrophenanthrene and 3 : 3-dimethyl-1 : 2 : 3 : 4-tetrahydrophenanthrene. On selenium dehydrogenation at 340° the former gave 2-methyl phenanthrene but the latter gave an inseparable mixture which seemed to contain phenanthrene and methyl-phenanthrene.

99. Formation and transformation of carbon ring compounds. Part VI.

S. C. SENGUPTA, Calcutta.

α-Methylnaphthalene and *unsymm*-dimethyl succinic anhydride condensed in presence of aluminium chloride giving $\alpha\alpha$-dimethyl-γ-

keto-γ-(4-methyl)-1-naphthyl-butyric acid (m.p. 202-203°), which on Clemmensen reduction gave $\alpha\alpha$-dimethyl-γ-(4-methyl)-1-naphthyl butyric acid (m.p. 105-106°). The latter on cyclization with 85% sulphuric acid gave 1-keto-2 : 2 : 9-trimethyl-1 : 2 : 3 : 4-tetrahydrophenanthrene (m.p. 123°) in almost theoretical yield. This cyclic keto compound on Clemmensen reduction gave 2 : 2 : 9-trimethyl-1 : 2 : 3 : 4-tetrahydrophenanthrene (m.p. 90-91°) which on selenium dehydrogenation at 340° gave 2 : 9-dimethylphenanthrene, melting at 55-56°.

100. A synthesis of chrysene.

S. C. SENGUPTA, Calcutta.

By an extension of the method developed for the synthesis of spiro-hydrocarbons and their ring transformation (*J Indian Chem. Soc.*, 1934, 389), the following synthesis of chrysene has been accomplished. The anhydride of *cyclo*pentane-1-carboxy-1-acetic acid reacted with naphthalene in presence of anhydrous aluminium chloride with the formation of $\alpha\alpha$-*cyclo*pentane-β-1-naphthoyl-propionic acid (m.p. 140-141°) and $\alpha\alpha$-*cyclo*pentane-β-2-naphthoyl-propionic acid (m.p. 190-191°). The former on reduction by the Clemmenson method gave $\alpha\alpha$-*cyclo*pentane-β-1-naphthyl butyric acid whence was prepared 1-keto-1 : 2 : 3 : 4-tetrahydrophenanthrene-2 : 2-spiro*cyclo*pentane (b.p. 215°/6 mm.). This spiro-ketone was reduced by the Clemmensen method to the spiro-hydrocarbon 1 : 2 : 3 : 4-tetrahydrophenanthrene-2 : 2-spiro-*cyclo*pentane, which on selenium dehydrogenation at 300–350° gave only chrysene and no trace of benzanthracene could be detected in the product.

101. Synthesis in the phenanthrene series.

S. S. AHUJA, K. S. NARANG, *and* J. N. RAY, Lahore.

6-Nitro-3 : 4-dimethoxybenzylidene benzyl cyanide (m.p. 179°) gives 6-amino-3 : 4-dimethoxybenzylidene benzyl cyanide (m.p. 154°) on reduction but the Pschorr synthesis on the latter did not succeed. Piperonylidene benzyl cyanide (m.p. 119°) nitrates to give 6-nitro-3 : 4-methylenedioxy benzylidene-cyanostilbene (m.p. 212°) which reduces to the *amino* compound (m.p. 177°); the Pschorr synthesis when applied to this compound also fails. 3 : 4-Dimethoxy-6-nitro-benzyl alcohol (m.p. 129°) prepared by Cannizzaro reaction on 6-nitroveratric aldehyde gives an acetyl derivative (m.p. 162°) and is converted easily to 6-nitro-3 : 4-dimethoxybenzyl chloride (m.p. 92°). The reaction of the latter with potassium cyanide gives two polymers, m.p. 167° and 234° respectively. Dimethoxybenzyl cyanide (m.p. 51°) nitrates to give 6-nitro-3 : 4-dimethoxybenzyl cyanide (m.p. 113°). This substance condenses with piperonal to give piperonylidene-6-nitro-3 : 4-dimethoxybenzyl cyanide (m.p. 198°). On reduction, this compound gave a substance in which amino group was absent.

6-Bromo-3 : 4-dimethoxybenzyl cyanide (m.p. 89°) condenses with 6-bromopiperonal to give cyano-3 : 4-dimethoxy-6-bromo-3′ : 4′-methylenedioxy-6′-bromostilbene. The action of copper on this compound is being tried.

102. Chalkones : 2-Methoxy styryl phenyl ketone.

N. A. BHAGVAT *and* T. S. WHEELER, Bombay.

The dibromide (II) of 2-methoxy-styryl-phenyl-ketone (I) when boiled with methyl alcohol and ethyl alcohol gives respectively α-benzoyl-α-bromo-β-2-methoxy phenyl-β-methoxy ethane (III) and α-benzoyl-α-bromo-β-2-methoxy phenyl-β-ethoxy ethane (IV). The action of pyridine on (I) leads to the unsaturated bromo ketone, α-benzoyl-α-bromo-β-2-methoxy-phenyl-ethylene (V). The action of chlorine on

(I) gives the dichloride, which in boiling methyl and ethyl alcoholic solutions is converted into the β-alkyloxy compounds analogous to (III) and (IV). Pyridine likewise converts the dichloride into the unsaturated chloroketone. (I) with bromine (2 mols) gives α-benzoyl-β-2-methoxy-5-bromophenyl-α-β-dibromo-ethane (VI). The β-bromine atom in (VI) is also reactive; it can be replaced by a methoxy or ethoxy group by the action of boiling methyl or ethyl alcohol, and can be eliminated as hydrogen bromide by pyridine, giving α-benzoyl-α-bromo-β-2-methoxy-5-bromophenyl-ethylene.

103. Chalkones and chalkone oxides. 2 : 4-Dimethoxyphenyl-3′ : 4′-methylenedioxystyryl ketone.

D. C. MOTWANI *and* T. S. WHEELER, Bombay.

In the present work the authors propose to study the effect of methoxy groups, in the ketone nucleus of the chalkone, on the reactivity of the bromine atoms of the chalkone dibromide. For this purpose 2 : 4-dimethoxyphenyl-3′ : 4′-methylenedioxystyryl ketone, m.p. 137-138°, has been prepared: (i) from 2 : 4-dimethoxyresacetophenone and piperonal, and (ii) from piperonal and resacetophenone and subsequent methylation of the resulting product. The chalkone has been prepared before by Goschke and Tambor (*Ber.*, 1911, 3504) by method (ii) who, however, give the m.p. as 168°. The dibromide of the chalkone is prepared from its solution in a mixture of carbon bisulphide and chloroform by the action of bromine. One of the bromine atoms shows the usual reactivity. Potassium iodide regenerates the chalkone from a solution of the dibromide in acetone solution. The oxide of the chalkone has been prepared by the action of alkaline hydrogen peroxide. Its derivatives have been prepared.

Further work is in progress.

104. Reactivity of *p*-Anisylidene-*p*-methylacetophenone.

S. M. NADKARNI *and* T. S. WHEELER, Bombay.

In continuation of the work on *p*-anisylidene-*p*-methylacetophenone (I) communicated last year, the dibromide, (II) of *p*-tolyl-4-methoxystyryl ketone (I) and the dibromide of *p*-tolyl-4-methoxy-3-bromo-styryl ketone (III) give with two molecules of sodium methoxide followed by hydrolysis, *p*-tolyl-4-methoxyphenyl diketone and a corresponding bromo-diketone which with copper acetate give green copper salts. (III) condenses with ethyl acetoacetate to yield ethyl 2-(4′-methoxy-3-bromophenyl)4-toluoyl-Δ^4-*cyclo*hexene-6-one-1-carboxylate (IV). This with hydrochloric acid under pressure gives 4′-methoxy-3-bromo-phenyl-4-toluoyl-Δ^4-*cyclo*hexenone (V).

The dichloride (VI) of (I) behaves in the same way as the dibromide mentioned before with regard to methyl and ethyl alcohol, pyridine, sodium methoxide (one mol), potassium iodide, etc. The same reactions are observed with the dichloride (VII) of *p*-tolyl-4-methoxy-3-chloro-styryl ketone (VIII). (VII) is obtained by the action of excess of chlorine on (I), and with two molecules of sodium methoxide followed by hydrolysis gives a chlorodiketone (IX) which with copper acetate gives a green chloro copper salt. (VIII) condenses with acetoacetic ester to give a chloro-ester and thence a chloro*cyclo*hexenone corresponding to (IV) and (V).

(VIII) with bromine or the dibromide of (I) with chlorine gives a chlorodibromide (X) which with methyl and ethyl alcohol gives a chloro-methoxy bromide and a chloro-ethoxy bromide respectively. (X) with pyridine or sodium methoxide (one mol) yields α-toluoyl-α-bromo-β-4-methoxy-3-chlorophenylethylene. Similarly *p*-tolyl-4-methoxy-3-bromo-styryl ketone gives with chlorine a bromodichloride (XI). (VI) with

bromine gives the same compound. (XI) gives with methyl and ethyl alcohols a bromo-methoxy chloride and a bromo-ethoxy chloride respectively. (XI) yields with pyridine or sodium methoxide (one mol) α-toluoyl-α-chloro-β-4-methoxy-3-bromophenyl-ethylene. The alkoxy chlorides give with HBr α-*p*-toluoyl-α-chloro-β: 4-methoxyphenyl-bromethanes.

105. Reactivity of piperonylidene-*p*-methylacetophenone.

A. M. Warrier *and* T. S. Wheeler, Bombay.

Extending the work on the reactivity of piperonylidene-*p*-methylacetophenone communicated last year, hydrolysis of the nitriles has been carried out. The action of two mols of sodium alkoxides on the dibromides of *p*-tolyl-3 : 4-methylene-dioxystyryl ketone (I) and *p*-tolyl-3 : 4-methylenedioxy-6-bromostyryl ketone (II) has been found to give ethers which with hydrochloric acid yield β-diketones. These diketones coloured ferric chloride (alcoholic) green and with copper acetate yielded the corresponding copper salts. *p*-Tolyl-3 : 4-methylenedioxystyryl ketone (III) and *p*-tolyl-3 : 4-methylenedioxy-6-bromo-styryl ketone condensed with ethyl acetoacetate to give ethyl 2-(3′ : 4′-methylenedioxyphenyl)-4-toluoyl-Δ^4-*cyclo*hexene-6-one-1-carboxylate (IV) and ethyl 2-(3′ : 4′-methylene-dioxy-6-bromo-phenyl)-4-toluoyl-Δ^4-*cyclo*hexene-6-one-1-carboxylate (V) respectively. (IV) and (V) on hydrolysis with hydrochloric acid under pressure yielded the respective *cyclo*hexenones. Chlorination of the parent substance was also carried out and compounds corresponding to the bromo compounds have been obtained. Several mixed halogeno compounds, with different kinds of halogen atoms, in the nucleus and in the side chain, as well as in the side chain only, have also been prepared.

106. Studies in Pechmann's and Simonis' reactions.

D. Chakravarti *and* B. Banerjee, Calcutta.

4-Chloro-*o*-cresol, 4-nitro-*o*-cresol, 2-chloro-*p*-cresol, 4-chloro-*m*-cresol and 2-nitro-*m*-cresol have been condensed with various α-alkyl-acetoacetic esters using sulphuric acid (Pechmann's reaction) and phosphorus pentoxide (Simonis' reaction) as condensing agents.

4-Chloro-*o*-cresol, 4-nitro-*o*-cresol and 2-nitro-*m*-cresol do not react with the esters in presence of sulphuric acid but in presence of phosphorus pentoxide chromones are obtained.

2-Chloro-*p*-cresol and 4-chloro-*m*-cresol form coumarins with sulphuric acid but chromones with phosphorus pentoxide. The coumarin formation is hindered with the introduction of heavier alkyl substituents in the acetoacetic ester molecule. The chromones have all been characterized by the formation of styryl derivatives.

It is found that Simonis' reaction on the formation of chromones can be facilitated by introducing halogen and nitro groups into the molecules of the phenols which do not satisfactorily respond to Pechmann's reaction.

107. Synthesis of 4-methyl-6-acetyl-8-ethyl-7-hydroxycoumarin.

(Miss) Indu Ghate, Poona.

(*Communicated by D. B. Limaye.*)

In continuation of the work of Limaye and Ghate (*Rasayanam*, 1936, **1**, 39), 2-ethyl-resorcin has been condensed with ethyl acetoacetate. The resulting 4-methyl-8-ethyl-7-hydroxycoumarin, $C_{12}H_{12}O_3$, m.p. 226°, gave an acetate, $C_{14}H_{14}O_4$, m.p. 105°, which on aluminium chloride treatment yielded 4-methyl-6-acetyl-8-ethyl-7-hydroxycoumarin, $C_{14}H_{14}O_4$, m.p. 166°, characterized by its acetate $C_{16}H_{16}O_5$, m.p. 104° and the

hydrolytic product, 2 : 4-dihydroxy-3-ethyl-β-methylcinnamic acid, $C_{14}H_{16}O_5$, m.p. 131–133° (with evolution of carbon dioxide). It forms a phenolic product, m.p. 68°–70°, when heated at its m.p.

The 4-methyl-6-acetyl-8-ethyl-7-hydroxycoumarin, m.p. 166°, is being used for obtaining a condensed ring system such as a furo-coumarin having an alkyl group in the 8-position.

108. On the limited applicability of Kostanecki's reaction.

D. Chakravarti *and* P. Bagchi, Calcutta.

4-Chloro-2-aceto-1-naphthol (m.p. 121°, phenylhydrazone, m.p. 158-159°), and 4-chloro-2-propio-1-naphthol (m.p. 88°), prepared respectively from the acetyl or propionyl derivative of 4-chloro-1-naphthol (Fries' rearrangement), have been submitted to Kostanecki's reaction. When heated with sodium acetate and acetic anhydride, these keto-naphthols form chromones : 4-chloro-2-aceto-1-naphthol gives 6-chloro-2-methyl-3-acetyl-1 : 4-αβ-naphthapyrone (m.p. 188-89°), 4-chloro-2-propio-1-naphthol gives 6-chloro-2 : 3-dimethyl-1 : 4-αβ-naphthapyrone (m.p. 182-83°), identical with the condensation product of 4-chloro-1-naphthol with ethyl methylacetoacetate in presence of phosphorus pentoxide (*Proc. Ind. Sci. Cong.*, 1936). With sodium propionate and propionic anhydride they yield coumarins, the coumarin from 4-chloro-2-aceto-1-naphthol being identical with the product obtained by condensing 4-chloro-1-naphthol with ethyl methylacetoacetate using sulphuric acid as the condensing agent. Using phenyl acetic anhydride and sodium phenyl acetate, 4-chloro-2-aceto-1-naphthol yields a coumarin e.g. 6-chloro-4-methyl-3-phenyl-1: 2-αβ-naphthapyrone (m.p. 215°) identical with the condensation product of 4-chloro-1-naphthol with ethyl phenyl acetoacetate in presence of sulphuric acid.

The results obtained are in agreement with the observations of Heilbron and co-workers (*J.*, 1933, 1263 ; 1934, 1311, 1581 ; 1936, 295).

109. Coumarin-carboxylic acids.

R. C. Shah *and* S. M. Sethna, Bombay.

Clayton (*J.*, 1908, 2016) showed that the carboxyl and the carbethoxyl groups in phenol inhibit Pechmann's coumarin condensation. It is now found that β-resorcylic acid, methyl β-resorcylate and *p*-orsellinic acid undergo the coumarin condensation readily with acetoacetic ester and malic acid giving the corresponding coumarin carboxylic acid derivatives. The constitutions of the coumarins have been established Further work is in progress.

110. Synthesis of coumarins and chromones from 4-bromo-1-naphthol and alkyl-acetoacetic esters.

D. Chakravarti *and* P. Bagchi, Calcutta.

4-Bromo-1-naphthol (Reverdin and Kaufmann, *Ber.*, 1895, 28, 3049) condenses with ethyl acetoacetate forming a coumarin, e.g. 6-bromo-4-methyl-1 : 2-αβ-naphthapyrone, m.p. 208°, with sulphuric acid or phosphorus pentoxide as condensing agent. With the introduction of an alkyl substituent in the acetoacetic ester molecule, however, as with ethyl methyl-acetoacetate 4-bromo-1-naphthol yields a coumarin, e.g. 6-bromo-3 : 4-dimethyl-1 : 2-α β-naphthapyrone, m.p. 188°, with sulphuric acid and a chromone (6-bromo-2 : 3-dimethyl-1 : 4-α β-naphthapyrone, m.p. 211-12°) with phosphorus pentoxide. The 1 : 4-naphthapyrone is characterized by the formation of the styryl derivative, m.p. 233°.

111. Synthesis of coumarins from phenol-carboxylic acids and β-ketonic esters.

D. CHAKRAVARTI *and* B. BANERJEE, Calcutta.

Clayton (*J.*, 1908, 2018) showed that nitrophenols and phenol-carboxylic acids do not respond to Pechmann's reaction and the halogenated phenols form coumarins in very poor yield. In continuation of the work of Chakravarti and Ghosh (*J. Indian Chem. Soc.*, 1935, **12**, 622; *Proc. Ind. Sci. Cong.*, 1935, 153) it has been found that the presence of a carboxyl group in those phenols which readily form coumarins does not inhibit the reaction. 7-Hydroxy-4-methyl-coumarin-6-carboxylic acid (m.p. 282°) is formed by condensing β-resorcylic acid with ethyl acetoacetate. The work on the condensation of other phenolic acids is in progress.

112. On the constitution of nitro-β-methyl-umbelliferone methyl ether and chloro-resorcin.

D. CHAKRAVARTI *and* B. BANERJEE, Calcutta.

The nitro-β-methyl-umbelliferone methyl ether (m.p. 281°) of Pechmann and Obermiller (*Ber.*, 1901, *34*, 666) has been shown to be 6-nitro-7-methoxy-4-methylcoumarin since on demethylation it gives 6-nitro-7-hydroxy-4-methylcoumarin (m.p. 255°), identical with the coumarin obtained by condensing 4-nitroresorcin with ethyl acetoacetate.

6-Chloro-7-methoxy-4-methyl-coumarin (m.p. 252°), obtained by Sandmeyer's reaction on 6-amino-7-methoxy-4-methylcoumarin (m.p. 120°), the reduction product of 6-nitro-7-methoxy-4-methyl-coumarin, is identical with the methoxy derivative of the coumarin obtained by the condensation of chloro-resorcin and ethyl acetoacetate. The chlorine atom in chlororesorcin, therefore, occupies the position 4 as shown by Clark (*J. Amer. Chem. Soc.*, 1933, 319) and Chakravarti and Ghosh (*J. Indian Chem. Soc.*, 1935, *12*, 791; *Proc. Ind. Sci. Cong.*, 1935, 152).

113. Use of 7-hydroxycoumarin in the Nidhone process for the syntheses of 2-acyl-resorcins and the preparation of 3-methyl-furocoumarins.

M. C. JOSHI, Poona.

(*Communicated by D. B. Limaye.*)

In continuation of Limaye's work on the syntheses of furocoumarins (linear and angular) and the Nidhone process (*Ber.*, 1932, *65*, 375; 1934, *67*, 12; Limaye and Gangal, *Rasayanam*, 1936, *1*, 15) the acetate of 7-hydroxycoumarin was treated with aluminium chloride when two isomeric acetyl umbelliferones were isolated, as in the case of 4-methyl-umbelliferone. The substance, m.p. 167°, which formed the major part of the reaction, was previously obtained by Limaye, and has been described by Ray, Silooja and Vaid (*J.*, 1935, 813) as the 8-acetyl-7-hydroxycoumarin. On hydrolysis with caustic alkali, it gave an acid of indefinite melting point, together with a small quantity of 2-acetyl-resorcin (Limaye and Gangal, *Proc. Ind. Sci. Cong.*, 1934, 229) confirming the structure of the substance as the 8-acetyl compound. The other substance, m.p. 177°, does not give 2-acetyl-resorcin on hydrolysis and hence it is the 6-acetyl-7-hydroxycoumarin.

The 8-acetyl-7-hydroxy-coumarin was successively converted into the 7-(carbethoxy-methoxy)-8-acetyl-coumarin, m.p. 117°, the 7-(carboxy-methoxy)-8-acetylcoumarin, m.p. 210–212° and the angular 3-methyl-7′: 8′-furocoumarin, m.p. 150°. The 6-acetyl-7-hydroxycoumarin when similarly treated gave the linear 3-methyl-7′: 6′ furocoumarin, m.p.

188°. A furocoumarin of the same structure and m.p. has been described by Ray, Silooja and Vaid (*loc. cit.*) who obtained it by condensing 7-hydroxycoumarin with chloroacetone.

114. Chalkones and flavones from 2-acetyl-resorcinol.

I. Z. Saiyed *and* T. S. Wheeler, Bombay.

It has been shown in the previous communication (*Proc. Ind. Sci. Cong.*, 1936) that 2-acetyl-resorcinol when condensed with various aldehydes in presence of alkali gave a mixture of chalkones and flavanones. Attempts to separate the two from their mixture were unsuccessful. With benzaldehyde, however, the flavanone (m.p. 302-303°) has been isolated.

The dimethyl ether of 2-acetyl-resorcinol has been condensed with benzaldehyde, salicylaldehyde, anisaldehyde, *o*-nitrobenzaldehyde, piperonal and *o*-chlorobenzaldehyde in presence of alkali. In all the cases chalkones have been readily obtained. The di- and tri-bromides of these chalkones and their reactions are being studied.

8-Acetyl-β-methyl-umbelliferone has also been condensed with anisaldehyde, *o*-chloro-benzaldehyde and *o*-nitrobenzaldehyde in presence of alkali and their corresponding compounds have been obtained with some difficulty.

4-Methoxy-5-hydroxy-flavone (m.p. 155°) has been obtained by Robinson's method from 2-acetyl-resorcinol, anisic anhydride, and sodium anisate. Its demethylation has led to 4′ : 5-dihydroxyflavone (m.p. 239-40°). The synthesis of the corresponding 5-hydroxyflavones from 3 : 4-dimethoxybenzoic acid, *o*-methoxy-benzoic acid, *m*-methoxybenzoic acid, 3 : 4-methylenedioxybenzoic acid and dimethyl- β-resorcylic acid, is in progress.

The dibenzoate (m.p. 106-7°) of 2-acetyl-resorcinol in presence of sodamide in ether, is converted into the diketone, which with concentrated sulphuric acid gives 5-hydroxyflavone.

From 2-acetyl-resorcinol, *o*-methoxy-dibenzoate, 3 : 4-methylene-dioxybenzoate and dianisate have been prepared and the sodamide reaction on them is being studied.

115. Di-flavones and di-flavonols.

D. R. Nadkarni *and* T. S. Wheeler, Bombay.

The di-ether (*J.*, 1936, 589) obtained in the condensation of epichlorohydrin or glyceryl chlorohydrin with resacetophenone has been treated with aldehydes to give several di-chalkones which have been converted into di-flavones and di-flavonols with selenium dioxide and 30% hydrogen peroxide, respectively.

116. The constitution of a colouring matter of *Digitalis lutea*.

H. S. Mahal *and* K. Venkataraman, Bombay.

The flavone colouring matter of *Digitalis lutea* (Adrian and Trillat, 1899) is not identical with 7-methoxy-4′-hydroxy-flavone ('*epi*pratol'). The latter has been synthesized by the oxidation of 2-hydroxy-4-methoxy-phenyl-4-benzyloxystyryl ketone with selenium dioxide, followed by debenzylation.

117. Synthetical experiments in the *iso*flavone group.

P. C. Joshi *and* K. Venkataraman, Lahore.

The action of trichloroacetic anhydride and potassium trichloroacetate on 2-phenylacetyl-1-naphthol gave a substance, which had the qualitative properties of 2-trichloromethyl-3-phenyl-1 : 4-naphthapyrone, but it could

not be crystallized and hydrolysis to the 2-carboxylic acid and decarboxylation to the naphtha*iso*flavone were not accomplished.

2 : 4-Dinitrobromobenzene condensed with α-formylphenyl-acetonitrile in pyridine solution to give 2 : 4-dinitrophenoxy-methylene benzyl cyanide. Saturation of an ethereal solution of the latter with hydrogen chloride gave a substance which was not the dinitro*iso*flavone, nor was it the pyrone-imide, being unaffected by boiling concentrated hydrochloric acid and syrupy phosphoric acid. Similarly the dinitrophenoxy-methylene phenylacetic ester was prepared; attempts to effect ring closure to the *iso*flavone were unsuccessful.

Condensing 2 : 4-dinitrobromobenzene with benzoylacetonitrile in presence of sodium ethylate, two substances, the *O*-phenyl and the *C*-phenyl derivatives were isolated. Treatment of the former with hydrogen chloride in ether yielded uncrystallizable material or the original compound.

In the Baker-Robinson method for the synthesis of *iso*flavones by the oxidation of 2-styryl derivatives the possibility of the use of the dinitrostyryl compound leading to more facile oxidation could not be examined, since 2 : 4-dinitrobenzaldehyde did not condense with 2-methyl-3-phenyl-1 : 4-α-naphthapyrone, which reacts readily with benzaldehyde, anisaldehyde and veratraldehyde.

β-Naphthol condenses with ethyl acetoacetate to give a chromone (Dey and Lakshminarayanan, *J. Indian Chem. Soc.*, 1932), but the α-pyrone was obtained in the case of α-formylphenylacetic ester.

118. The isolation of an anthocyanin pigment from the rind of sugar cane (*Purple Mauritius*).

C. J. DAṢARAO, D. G. WALAWALKAR, *and* B. S. SRIKANTAN, Waltair.

The anthocyanin pigment occurring on the rind of the *purple mauritius* cane has been isolated and identified to be a diglucoside of the monomethyl-ether of delphinidin, possibly ampelopsidin. It has an absorption band at 4400–4800 A°.

119. Synthetical experiments on 5 : 8-dihydroxyflavone and on 5 : 6 : 7- and 5 : 7 : 8-trihydroxyflavones.

G. K. BHARADWAJ *and* K. VENKATARAMAN, Lahore.

The oxidation of chrysin by means of chromic anhydride and with other oxidising agents (nitric acid, potassium persulphate, selenium dioxide) has not led to any homogeneous material other than the starting substance. Oxidation of 5-hydroxy-6-benzyl-7-benzyloxyflavone also gave negative results. The ready oxidisability of pyrogallol trimethyl ether to 2 : 6-dimethoxyquinone suggested that the oxidation of 7 : 8-dihydroxyflavone may lead to norwogonin. Numerous attempts, however, to oxidise 7 : 8-dihydroxyflavone, its dibenzyl ether and dimethyl ether were fruitless. If the dibenzyl ether had been successfully oxidised to the quinone a route to wogonin would have become available.

The persulphate oxidation of 7 : 8-dibenzyloxycoumarin with the object of preparing the 6-hydroxy derivative, which could then be converted through obvious steps to fraxetin, did not proceed as desired, daphnetin being recovered in some cases and the odour of benzaldehyde, indicating debenzylation and oxidation of the benzyl chloride, noticed in others.

An attempted synthesis of baicalein through 2 : 6-dimethoxy-3-acetylbenzoquinone and 2 : 4-dimethoxy-3 : 6-dihydroxyacetophenone broke down at the first stage of the oxidation of gallacetophenone trimethyl ether by means of nitric acid.

The synthesis of wogonin is in progress, involving the partial demethylation of 5 : 8-dimethoxy-7-hydroxyflavone, prepared by the selenium dioxide oxidation of the chalkone derived from 2 : 4-dihydroxy-3 : 6-dimethoxyacetophenone.

With regard to methods for the synthesis of the colouring matter of *gingko biloba* and the synthesis of primetin, the coupling of 8- and 6-hydroxyflavone with diazobenzene chloride and with slow-coupling diazo salts is being studied.

120. The constitution of gardenin.

P. K. Bose *and* R. Nath, Calcutta.

Gardenin of Stenhouse and Groves (*Annalen*, 1880, *200*, 311) is a derivative of heptahydroxyflavone. It contains six methoxy and one hydroxy groups. The latter is present in the benzopyrone nucleus but not in position 3. Three methoxy groups occupy 3′ : 4′ : 5′-positions. Acetyl and methyl-gardenin are described. 'Gardenic acid' is a quinone formed by loss of a methyl group. The several possibilities are discussed.

121. On the exudation from *Celtis cinnamomea* Lind. Isolation of skatol.

P. R. Krishnaswamy *and* B. L. Manjunath, Bangalore.

The finely powdered product, on steam distillation, yielded pure skatol (35 per cent.). It is of interest to note that skatol occurs in *Celtis reticulosa* Mig, and *Celtis durandii* Engl. (*cf.* Wehmer, '*Die Pflanzenstoffe*', 1929, II, 235).

122. The action of selenium oxychloride on diaryl secondary amines.

K. S. Venkat Raman *and* P. S. Varma, Benares.

The selenium analogue of diphenylthiazine and its derivatives have been prepared by heating diarylamines with selenium dichloride in benzene solution (Weizmann and Stephen, 1913, Wilhelm and Cornelius, *J. pr. Chem.*, 1913, ii, *88*, 395–408). As selenium oxychloride gave rise to selenides but not selenoxides with tertiary amines, it was expected that with diaryl-amines, it may give diphenyl thiazine derivatives. But the products obtained from (1) diphenylamine, and (2) phenyl α-naphthylamine are highly coloured, difficultly soluble in the common organic solvents, but soluble in pyridine and amines and contain chlorine. Probable structures of the compounds have been advanced.

The selenium compound so obtained from diphenylamine on nitration with concentrated nitric acid, gives a nitro derivative, soluble in alcohol, and dissolves in aqueous alkali yielding strawberry red solution. The action of selenium oxychloride on other diaryl amines is under investigation. Attempts are being made to prepare selenazine derivatives by the action of selenium on diarylamines, in presence of anhydrous aluminium chloride on the lines similar to the preparations of the corresponding thiazine compounds (Bernthsen, *Ber.*, 1883, *16*, 2897 ; *Annalen*, 1885, *230*, 77).

123. The action of selenium oxychloride on tertiary amines.

K. S. Venkat Raman *and* P. S. Varma, Benares.

Whereas the action of selenium oxychloride on phenols has been thoroughly studied (Michaelis and Kunckell, *Ber.*, 1895, *28*, 609 ; 1897, *30*, 2823 ; Morgan and Burstall, *J.*, 1928, *130*, 3260) the reaction with amines has not been so well investigated. It has been reported that

selenium oxychloride reacts with dimethyl and diethyl anilines to give rise to tetra alkyl diamino-diphenyl selenide (Godchaux, *Ber.*, 24, 765). On repeating the experiment it was found that the yield of the compound was poor. The isolation of the compound was found to be rather tedious and there was much loss of material. By changing the conditions of the experiment it has been possible to prepare and isolate the compounds in comparatively good yields in a purer condition. With selenium oxychloride, methyl benzyl aniline gives di- (methyl benzyl-amino phenyl) selenide, m.p. 116°. The reaction with primary amines and other secondary amines is under investigation.

124. Constitution of Guareschi's pyridine derivative.

NIRMALANANDA PALIT, Patna.

Guareschi's compound, m.p. 222-223° (*Chem. Zentr.*, 1897, 927; 1907. I, 332) which has been obtained by revised method from benzylidene-acetoacetic ester and cyanoacetamide with diethylamine as the condensing agent (*Proc. Ind. Sci. Cong.*, 1936) is now shown to be 2-ethoxy-2-hydroxy-3-aceto-4-phenyl-5-cyano-6-keto-hexahydropyridine (I).

Its constitution is based on (*a*) the formation of a dimethoxy derivative (II), (*b*) its transformation with acetic anhydride into 2-keto-3-aceto-4-phenyl-6-ketopiperidine (III), (*c*) with phosphorus trichloride in hot benzene into 2-keto-3-aceto-4-phenyl-5-cyano-6-ketopiperidine (IV), and (*d*) by the analogy with the condensation product obtained from benzylidene-cyanacetic ester and cyanoacetamide with diethylamine as the condensing agent which is 2-diethylamino-2-hydroxy-3-cyano-6-phenyl-5-cyano-6-ketopiperidine (V).

That (V) is not an open chain derivative but a ring compound is proved by its ready transformation into 2-keto-3-cyano-4-phenyl-5-cyano-6-oxyquinoline (VI) which has been previously obtained by Day and Thorpe (*J.*, 1920, 1473) by a different method and whose constitution has been established.

125. Quinoline derivatives. Part I.

T. N. GHOSH, Bangalore.

Antipyrine has greater antipyretic activity than quinine, but has no specific action against malaria. It was, therefore, thought that quinoline derivative with fused pyrazolone ring will have antipyretic activity combined with antimalarial properties. 1-Phenyl-3-methyl-pyrazolone has now been condensed with anthranilic acid to yield a pyrazolinoquinoline derivative.

The condensation of hippuric acid with anthranilic acid, in presence of fused sodium acetate, has been studied.

Urethanylacetic ester has been condensed with *o*-nitrobenzaldehyde to yield α-urethanyl-*o*-nitrocinnamic ester. Attempts are being made to reduce this nitro compound with various reducing agents.

126. Quinoline derivatives. Part II.

T. N. GHOSH, Bangalore.

Therapeutic activity of thiazole and benzthiazole derivatives is well known. It was, therefore, thought that thiazole quinoline derivatives will possess important therapeutic properties.

When treated with acetic anhydride, thiocarbamidoacetic acid is easily converted into a thiazole derivative which, due to the presence of a reactive methylene group, readily condenses with *o*-nitrobenzaldehyde, the product yielding a thiazolequinoline derivative on reduction.

127. Indigoid vat dyes of the isatin series. Part II.

S. K. GUHA, Patna.

The present investigation was undertaken with the object of preparing 3-indole-2′-(6′-methyl)-thionaphthene-indigos and comparing them with those of the corresponding 5-methyl compounds (Guha and Basu-Mallick, *J. Indian Chem. Soc.*, 1934, *11*, 395). It was intended to examine how far Martinet's rule (*Rev. Gen. Mat. Col.* 1921, *25*, 17) is obeyed by 3-indole-2′-thionaphthene-indigo commercially known as Thioindigo Scarlet R (Bezdzik and Friedlander, *Monatsh*, 1908, *29*, 376; E.P. 17162-06; D.R.P. 241327) and its derivatives (Ciba red G.E.P. 19158-07; G.P. 277358) having one methyl group present in the thionaphthene nucleus of the molecule. Isatin and its various substitution products and also phenanthraquinone were condensed with 6-methyl-3-hydroxy-thionaphthene and the corresponding indigoid dyes obtained. Their properties have been investigated.

128. Synthesis of arsindole derivatives.

H. N. DAS GUPTA, Calcutta.

The action between phenyl acetylene and phenyl arsenious chloride has been studied and it has been found possible to isolate an addition product in which Cl and PhAsCl serve as addenda to the triple bond.

The above compound when subjected to Friedel and Crafts' reaction leads to the production of 1-phenyl-3-chloro-arsindole (arsindole = indole in which NH is replaced by AsH).

129. Investigations of the constitution of 'artostenone', a keto-compound related to sterols, present in an Indian summer fruit '*Artocarpus integrifolia*'. Part I. Isolation and purification of artostenone.

M. C. NATH, Dacca.

1. Artostenone, a solid ketone, isolated from the fruit of *Artocarpus integrifolia* has the composition $C_{30}H_{50}O$, m.p. 109°.
2. It is highly soluble in most of the organic solvents.
3. Its specific rotation is $[\alpha]_D^{20} = 19{\cdot}86$ in absolute alcohol

and $[\alpha]_D^{20} = 23{\cdot}44$ in chloroform.

4. The molecular weight as determined by cryoscopic method is 407·3, that from X-ray data is 418 and the molecular elementary composition, as obtained by combustion results, suggests the molecular weight to be 426.
5. The density of artostenone, as found by suspension method, is 1·08.
6. It gives a monoxime, m.p. 175° and semicarbazone, m.p. 202-3°.
7. It gives some of the colour reactions of sterols, Kahlenberg's reaction which is specific for ergosterol being most pronounced.
8. Artostenone is an unsaturated compound.

130. Investigations on the constitution of 'artostenone'. Part II. Double bond in artostenone.

M. C. NATH, Dacca.

1. Artostenone is an unsaturated compound with only one double bond.
2. Number of bromine atoms which enter a molecule of artostenone, on bromination in carbon tetrachloride solution is four.

3. Two bromine atoms enter the molecule by substitution and the remaining two by addition.
4. The tetrabromo compound has been isolated and the percentage of bromine has been found to be 43·4 (Piria and Schiff's method).
5. Iodine value of artostenone has been found to be 60·2, one double bond requiring 61·6.
6. Artostenone is transformed into a saturated compound by catalytic hydrogenation with platinum black at 65–70°.

131. Investigations on the constitution of 'artostenone'. Part III. Reduction of artostenone to artostanone and artostenol.

M. C. NATH, Dacca.

1. Catalytic hydrogenation with platinum at 65°–70° saturates the double bond of artostenone, but retains the keto group unchanged.
2. Probability of the presence of the keto group in ring I, has been excluded; it has been suggested that the double bond in artostenone is in $\alpha\beta$-position with respect to the keto group.
3. Artostanone, the hydrogenation product of artostenone, has been isolated, m.p. 106°-107°.
4. Artostenone gives an oxime, m.p. 193-194°.
5. By method of reduction with sodium ethylate, the keto group is changed to hydroxyl, but the double bond remains intact. It has been proposed to call this product as artostenol.
6. Artostenol melts at 106-7° and its iodine value is 60.
7. Sodium amylate also reduces the keto group to hydroxyl.
8. The acetyl derivative of artostenol melts at 120-121°.
9. The acetyl derivative of the compound has m.p. 119-120°.

132. Investigation on the constitution of 'artostenone'. Part IV. Preparation of artostenamine and its complex with platinichloride.

M. C. NATH, Dacca.

1. Artostenone has been converted to an amine, artostenamine (m.p. 169-170°) through its oxime.
2. This amine is insoluble in strong hydrochloric acid but is soluble in glacial acetic acid.
3. Two molecules of this amine combine with one molecule of H_2PtCl_6 to form a complex, artostenamine-platinichloride.
4. The molecular weight of this complex has been found by Pregl's micro-muffle method to be 1291.
5. From this the molecular weight of artostenone has been calculated to be 440·5 ($C_{30}H_{50}O$ requiring 426 as the M.W.).
6. The platinum complex has C, 56·88 and H, 8·5%: $(NH_2{\cdot}C_{30}H_{52}, HCl)_2PtCl_4$ requires C, 57·05; H, 8·1%.

133. On Aristolochine, the principal alkaloid of the roots of *Aristolochia indica* Linn.

P. R. KRISHNASWAMY *and* B. L. MANJUNATH, Bangalore.

This paper deals with the preliminary investigation on the constitution of *aristolochine*, $C_{17}H_{19}O_3N$, isolated from the roots of *Aristolochia indica* Linn. (Krishnaswamy, Manjunath and Venkata Rao, *J. Indian Chem. Soc.*, 1935, 7, 476).

Aristolochine m.p. 215°; $[\alpha]_D^{25°}$, —·268·8°, gives a mono-hydrochloride, $C_{17}H_{19}O_3N$, HCl (decomp. at 268°). It forms additive com-

pounds of the general formula $(C_{17}H_{19}O_3N)_2.C_6H_5X$ (where X = H or Me) with benzene and toluene. The molecule contains one methoxyl group, one active hydrogen atom and one dimethylamino group.

Further work is in progress.

134. Chemical examination of the roots of *Bragantia wallichii*.

P. R. Krishnaswamy *and* B. L. Manjunath, Bangalore.

A brief note on the preliminary investigation has already been communicated (Manjunath and Venkatasubbiah, *Proc. Ind. Sci. Congress*, 1930, 183). This paper deals with the further work on the subject.

The oil from the roots was found to consist mainly of the glycerides of palmitic, stearic and lignoceric acids, and of oleic, linolic and linolenic acids. Among the other products isolated, mention may be made of *iso*-aristolochic acid (*J. Indian Chem. Soc.*, 1935, 7, 476) and of a basic substance in the form of its hydrochloride. Attention is drawn to the fact that *Bragantia wallichii* belongs to the species of *Aristolochiacœ*.

135. Investigation of *Momordica charantia* Linn. Part I.

N. K. Sen *and* B. K. Banerjee, Dacca.

Momordica charantia (Karala in Bengali) in a finely powdered condition was extracted successively with various solvents.

Petroleum ether extract yielded a brown fatty residue which on saponification gave a mixture of fatty acids from which palmitic and stearic acids were isolated. From the unsaponifiable matter a sterol, m.p. 132°–134°, was obtained.

Ether and chloroform extracts contained mainly chlorophyll mixed with some fatty matter, from which nothing definite could be isolated

Alcoholic extract yielded a bitter resinous substance which could be obtained in the form of an amorphous powder by repeated purification from a mixture of petroleum ether and chloroform. On hydrolysis it yielded a reducing sugar probably glucose, which gave an osazone, m.p. 205°, and an amorphous non-bitter aglucone indicating the glucosidic character of the substance. The bitter substance foams in aqueous solution and gives some of the characteristic properties of saponin.

Further investigation on this substance is in progress.

136. Isomerism of butane- $\alpha\beta\gamma\delta$-tetracarboxylic acids.

P. C. Guha *and* C. Krishna Murthi, Bangalore.

The isomerism of the two (high and low melting) butane $\alpha\beta\gamma\delta$-tetracarboxylic acids and their derivatives has been discussed. Some new methods of their syntheses have been worked out.

137. *para*-Bridging of succinosuccinic ester.

P. C. Guha, Bangalore.

In continuation and extension of the work reported (*Ind. Sci. Cong.*, 1936), the two bridged esters, m.p. 112° and 132°, respectively have each yielded more than one product on treatment with varying quantities of alcoholic potash. The action of oxidising agents such as permanganate and hypobromite is now described. Some synthetic experiments with a view to obtaining the degradation products (by the action of alkali) are also described.

138. Synthetic production of terpineol from pinene.

B. G. S. Acharya *and* T. S. Wheeler, Bombay.

Attempts are being made to improve the proportion of terpineol by known methods through the intermediate preparation of terpin hydrate from pinene contained in turpentine. Pinene and dilute sulphuric acid are shaken vigorously when crystals of terpin hydrate are copiously formed. This reaction is found to be accelerated by the use of substances like gum arabic, turkey red oil, etc. which act as emulsifying agents. Terpin hydrate is then boiled with dilute oxalic acid when terpineol is formed. Preparation of terpineol through acetylation of pinene and subsequent hydrolysis of the resulting terpineol acetate gave poor yields.

139. Synthetical experiments in the thujane series. Part I.

P. C. Guha *and* S. Krishnamurthi, Bangalore.

By the modification of older method, it has been possible now to obtain quite an excellent yield of α-methyladipic acid from *meta*-methyl-*cyclo*hexanone. Ethyl α-methyladipate has been converted into ethyl 3-methyl-Δ^1-*cyclo*pentene carboxylate *via* the 2-keto and 2-hydroxy compounds. The action of diazomethane and diazoacetic ester upon the methyl *cyclo*pentene ester under varying conditions is described.

140. Synthetical experiments in the thujane series. Part II.

P. C. Guha *and* Bhola Nath, Bangalore.

In this paper are described the results of our experiments in the preparation of 1 : 3-dibromo-hexahydro-*p*-toluic acid starting from *p*-toluic acid, *via* *p*-toluic-3-sulphonic acid, 3-hydroxy-*p*-toluic acid, 3-hydroxy-hexahydro-*p*-toluic acid, 3-bromo-hexahydro-*p*-toluic acid. 1:3-Dibromo-1-methyl-*cyclo*hexane-1-carboxylate is expected on treatment with zinc, to yield a compound possessing the thujane skeleton. 2 : 6-Dibromo-3-methyl-6-*iso*propyl-*cyclo*hexan-1-one prepared from menthol *via* menthone, will be subjected to the same process of debromination with zinc, for the preparation of the corresponding compound isomeric with thujone.

141. Experiments towards the synthesis of derivatives of bicyclo- (0 : 3 : 3)-octane ring system.

P. C. Guha *and* S. K. Ranganathan, Bangalore.

Having achieved the synthesis of *cis*-1-acetyl*cyclo*pentane-2-carboxylic acid (*Proc. Ind. Sci. Cong.*, 1936), some preliminary experiments were performed on the ring closure of its ethyl ester with sodium. The results obtained show that a 1 : 3-diketone is formed, isolable through its copper salt. Large amounts of the diketone are being prepared for a study of its properties. The work on the synthesis of *trans*-1-acetyl*cyclo*pentane-2-carboxylic acid along the lines adopted for the *cis*-acid has been described.

142. A resolution of bicyclo-(2 : 2 : 2)-octane-2 : 5-dione-1 : 4-dicarboxylic acid.

P. C. Guha *and* S. K. Ranganathan, Bangalore.

The synthesis of bicyclo-(2 : 2 : 2)-octane-2 : 5-dione-1 : 4-dicarboxylic acid, starting from succinosuccinic ester, has been reported by one of us (*Current Science*, June 1936), and it was thought that a resolution of the acid would, in addition to its intrinsic interest, offer an additional proof of the correctness of its constitution. For this purpose the acid was

combined with brucine (2 molecules) when a salt separated. Specific rotation of the brucine salt after 5 recrystallizations was $[\alpha]_D^{65°} = -70·87$ ($c=2·25$ in pyridine). The acid liberated from the salt had $[\alpha]_D^{25°} = +23·85°$ ($c=2·13$ in water). The mother liquor (of the brucine salt) yielded on three successive evaporation and filtration the pure salt of the *l*-acid which when liberated free had $[\alpha]_D^{28·5°} = -23·24°$ ($c=0·99$ in water). With the same thermometer the inactive, *d*- and *l*- forms were found to melt at 268°, 271° and 271°, respectively.

143. Experiments towards the synthesis of *iso*fenchone and its derivatives.

S. K. RANGANATHAN, Bangalore.

Ethyl αα-dimethyl lævulate (ethyl mesitonate) b.p. 108–110°/25 mm. has been condensed with zinc and ethyl bromoacetate to yield the lactone of ethyl β-hydroxy-βδδ-trimethyl adipate, b.p. 137-38°/6 mm. The lactone was converted through the intermediate β-cyano-βδδ-trimethyl adipic acid to βδδ-trimethyl-butane-αβδ-tricarboxylic acid, m.p. 169°; ethyl ester (alc. vapour method), b.p. 125–28°/1·2 mm. The ethyl ester has been cyclised by sodium in benzene to the ethyl *cyclo*pentanone-5 : 5-dimethyl-2 : 3-dicarboxylate, b.p. 158–161°/3 mm. Experiments are in progress for the confirmation of the constitution of the ketonic monocarboxylic acid obtained from the above by hydrolysis followed by decarboxylation.

144. Synthesis in the carane series.

P. C. GUHA *and* D. K. SANKARAN, Bangalore.

The sodium derivative of Guareschi imide on being condensed with tetramethylenedibromide gave the imide of 1 : 1-dimethyl-2 : 6-dicyano-*cyclo*heptane-2 : 6-dicarboxylic acid, m.p. 303°. Hydrolysis of the product with 1½ per cent. sodium hydroxide gave a nitrogenous compound m.p. 250° which on further hydrolysis with 15 per cent. sodium hydroxide yielded *cyclo*heptane-2 : 2 : 6 : 6-tetracarboxylic acid. The above tetra basic acid, on decarboxylation at 130–140° gave *cyclo*heptane-2 : 6-dicarboxylic acid (I), m.p. 134-135°.

The αα-dibromo derivative of (I) is expected to give *apo*carane dicarboxylic acid on treatment with zinc.

145. Synthesis in the pinane series. Part III. Towards the synthesis of pinocamphone and nopinane.

P. C. GUHA *and* K. GANAPATHI, Bangalore.

The syntheses of *iso*nopinone, nopinane and also pinocamphone, which will amount to a total synthesis of α and δ-pinenes, have been investigated as follows: The diethyl ester of the *trans*- or *cis*-norpinic acid is reduced by means of sodium and absolute alcohol to the same glycoll (*cf.* Ostling, C., 1921, *3*, 105), a very viscous liquid, b.p. 125–128°/4 mm., which (shown to be of the *trans*-configuration) by the action of PBr_3 yields the di-bromide, b.p. 100-102°/4 mm. With KCN in alcoholic solution, the dibromide gives the dicyanide, b.p. 142–45°/6 mm., which on hydrolysis with aqueous potash furnishes in good yield *sym*-homopinic acid (I), m.p. 120-21°, (dianilide. m.p. 216-217°). It is expected

to possess the *trans*-configuration. The diethyl homopinate, b.p. 133-135°/3 mm., by the action of sodium in xylene solution yields a product exhibiting the properties of a β-ketonic ester (II). The conversion of (II) into (*a*) *iso*nopinone (III) (by hydrolysis and decarboxylation), (*b*) nopinane (IV) (by reduction of the latter), and (*c*) pinocamphone (V) (by decarboxylation of the methylated product) are in progress.

The bicyclic compounds obtained in this series are expected to be of the *trans*-series, while those found in nature are all of the *cis*-type. The isomerism and the significance of this work from the point of view of the Sachse-Mohr theory are discussed.

This work was done with experimental co-operation of Messrs. D. K. Sankaran and V. K. Subramanyan.

146. Studies on optical activity and chemical constitution of optically active bases and acids. Part IV.

MAHAN SINGH *and* H. B. DUNNICLIFF, Lahore.

Camphor has been condensed with dimethylaminobenzaldehyde and camphoric anhydride and oxymethylene camphor have been condensed with dialkylaminoanilines.

p-Dimethylaminobenzylidene camphor has $\alpha_D = 731°$, whereas benzylidene camphor has only $\alpha_D = 425°$.

p-Dialkylaminocamphoranilic acids have been examined polarimetrically in various solvents. There is no definite order in which the dialkylamino groups can be arranged. The compounds in some cases are also examined in the presence of hydrochloric acid and in every case a slight increase is recorded.

The dialkylamino groups have brought a very small change in the rotation constants of anilinomethylenecamphor.

147. Asarone.

K. S. SUBRAMANIAN *and* B. SANJIVA RAO, Bangalore.

The liquid asarone from *Acorus calamus* gives the same pseudonitrosite as solid propenyl asarone. The liquid gave 10 per cent. yield of solid dibromide while the solid gave 50 per cent. of the same dibromide. Potash fusion of the liquid gave an excellent yield of the solid asarone. The liquid appears to be a mixture of *cis*- and *trans*- propenylasarone.

148. Experiments on the synthesis of new local anæsthetics.

K. N. GAIND, J. N. RAY, *and* A. WAHAB, Lahore.

A detailed study has been undertaken to establish the factors which impart local anæsthetic property to a compound. In this connection, the condensation products of α-hydroxy-β-chlorobutyric esters with piperidine have been acylated with various acids. The ester grouping has also been varied from methyl up to butyl. All the compounds possess very strong local anæsthetic property as tested by the rabbit's cornea method and give stable sterilizable salts. The condensation product of two molecules of piperidine with one molecule of epichlorohydrin has also been prepared. The resulting compound has been acylated with various acids and the properties of the products studied. In every case there is a strong local anæsthetic action observable.

149. Condensation of furil and furoin.

A. C. SIRCAR *and* S. C. GUHA, Calcutta.

Benzil and benzoin are very well adapted for various types of condensations (Japp and Hooker, *J.* 1884, 672 Japp and Robinson, *J.*

1882, 326; Anscutz and Geldermann, *J.* 1891, A, i, 725; Japp and Murray, *J.* 1894, 889; Japp and Meldrum, *J.* 1899, 1037, etc.). Many of these condensation products are very interesting both from the theoretical as well as practical point of view. It was, therefore, expected that the heterocyclic compounds furil and furoin would also yield a series of similar condensation products. In the present paper a large number of such condensation products has been described.

150. Photosensitising dyes. The preparation of the alkiodides of picoline and their subsequent condensation with *p*-dimethylaminobenzaldehyde.

M. Q. DOJA, Patna.

Mills and Pope (*J.* 1922, *121*, 946) prepared 2-*p*-dimethylamino-styryl-pyridine-methiodide by the interaction of α-picoline methiodide and *p*-dimethylamino-benzaldehyde. This compound was found to be a powerful sensitiser for green light, a region for which it is usually difficult to get a suitable sensitiser. It was expected that the photographic characteristics of this compound will change with the nature of the alkyl radical attached to the quaternary nitrogen atom. With a view to a systematic investigation of this problem, the ethyl, propyl, butyl and amyl iodides of α-picoline have been prepared and condensed separately with *p*-dimethylaminobenzaldehyde. In each case a new photosensitising dye has been obtained.

151. Simultaneous determination of chlorine, nitrogen and arsenic in organo-arsenic compounds.

H. N. DAS GUPTA, Calcutta.

No method is as yet known the adoption of which would lead to the simultaneous determination of the above three elements. The present method consists in digestion of organo-arsenic compounds containing chlorine or nitrogen or both in a mixture of sulphuric acid and potassium sulphate with a small amount of metallic selenium. The digestion requires about 45 minutes for completion. The halogen is evolved as hydrochloric acid which is absorbed in alkali and estimated. The nitrogen is liberated as ammonia on treating the cooled digest with alkali and the residual arsenic is estimated iodometrically.

152. Tannic acids from myrobolan.

S. R. SUNTHANKAR *and* S. K. K. JATKAR, Bangalore.

The following acids were prepared in a pure form from myrobolan extract previously reported: elagic, elagitannic, chebulinic and gallic. The various physico-chemical constants of these acids such as optical activity, dispersion and basicity (as determined by the potentiometric methods developed in our laboratory) were compared with the similar properties of Kahlbaum and E.de.Haen samples. The properties of inks prepared from these acids are also reported in this paper.

Industrial Chemistry

153. The fastness of the naphthol colours. Part I.

R. B. FORSTER, P. R. MEHTA, S. R. RAMACHANDRAN, *and* K. VENKATARAMAN, Bombay.

About 20 per cent of the synthetic dyestuffs consumed by the Indian textile industry being represented by the insoluble azo colours, the

fastness of the prevailing combinations has been studied. The experiments on kier boiling have been conducted in a small and specially designed pressure kier in which the conditions approximated to those in technical practice. The dye-stuff on the fibre was estimated in terms of the nitrogen content. A new technique has been developed for studying the fastness to rubbing, employing a Kleinewefers yarn mercerising machine. No linear relationship could be traced between the substantivity of a naphthol and the fastness of a dye derived from it. Since, however, substantive naphthols in general lead to comparatively fast dyeings and since symmetrical structure in a naphthol is favourable to substantivity, new and symmetrically constituted members of the Naphthol AS series have been prepared. The factors governing fastness to rubbing are discussed. Thus it is shown that the replacement of a stabilized diazo salt by a freshly diazotized solution of the base is not always an advantage. The addition of formaldehyde to the naphtholating bath increases rubbing fastness. The influence of the concentration of the after-treatment soap solution and of the time of soaping has been quantitatively examined. The rubbing fastness of the same combination is not identical in the case of cotton and viscose, and the difference is not always in the same direction for various combinations.

154. The interaction of diazo salts with silk.

R. B. Forster, S. R. Ramchandran, *and* K. Venkataraman, Bombay.

The tyrosine of the silk fibre couples with diazotized amines to give dyeings of yellow and brown (compare Sisley *et al*, 1931). Using the stabilized diazo salts, shades ranging from old gold to deep reddish and olive browns have now been obtained; buffering is essential for the production of full shades. The dyeings are characterized by fastness to washing. By dyeing silk with direct, basic or acid colours containing free amino groups and after-treating with nitrous acid, a large range of fast and attractive shades is available. Beautiful two-colour effects are produced by treating unions of silk and cotton or silk and viscose with a stabilized diazo salt or by dyeing a solid shade with a substantive colour and after-treating with nitrous acid.

The mechanism of the action is discussed.

155. Sugars in mohua flowers.

D. G. Walawalkar, Waltair.

The reducing and non-reducing sugars have been estimated and an attempt has been made for the preparation of a solid product out of the mohua syrup.

156. Furfural and other by-products from water hyacinth.

Sasanka Dey *and* H. K. Sen, Ranchi.

Recently a mass eradication by manual collection of water hyacinth (*Eichornia crassipes*), spreading, according to an official report, over an area of 4,269 sq. miles in the lower districts of Bengal, has been emphasized upon. How far the pest can be combated in this way remains to be seen. In any case, the utilization of the weed would lead to the winning of certain important technical products, for which there is already demand in this country, and future development of interdependent industries can also be visualized. It is calculated that there are at least 107 million tons of green or 5·3 million tons of air-dried hyacinth in Bengal, which can yield 0·3 million tons of furfural, 0·53 million tons of potassium

chloride, 56 million gallons of alcohol, 0 8 million tons of acetic acid, 0·18 million tons of acetone, and 2·12 million tons of compressed fibre.

Methods of technically separating the different products have been described, and balance sheet supplied. Furfural can be produced at 3 annas per pound, whilst the prevailing price in large bulks in America is 10 cents.

157. Fuel consumption in sugar factories. Part I.

M. R. MANDLEKAR, Bangalore.

As an outcome of an investigation into the problem of extraneous fuel consumption (e.g. wood and coal) in sugar factories, the chief sources of the loss of thermal efficiency of the boiler installations have been found to be :

1. Unsystematic methods of feeding 'bagasse' on to the step-grate furnaces resulting in fluctuating furnace conditions.
2. Uncontrolled admission of cold air to furnaces causing (*a*) reduction of combustion temperature, and (*b*) incomplete combustion of fuel.
3. Hot gases which leave the flues at a sufficiently high temperature (usually over 550°F.).
4. Other sources, e.g. exhaust steam, radiation losses, steam leakages, multiplication of working units with high capacities for heat, etc.

158. Fuel consumption in sugar factories. Part II.

M. R. MANDLEKAR, Bangalore.

The following remedies have been found to have successfully overcome the loss of efficiency occurring through various sources, and extraneous fuel costs can be reduced to an appreciable extent :—

1. A special design of the boiler furnace for wet bagasse (50% moisture) is necessary, slope of the grate being nearly 55°. Combustion chamber should provide a drying zone for bagasse before the fuel catches fire. The products of combustion should be required to travel just enough length of furnace and at such velocity as would enable the deposition of ash and suspended material to be kept back. Mechanical stoking arrangements are used with great advantage in large installations.
2. Enough exhaust steam is available to heat feed water and therefore economizers can conveniently be replaced by arrangements for heating the air required for combustion. Waste heat of the flue gases can thus be returned to the furnace. Air requirements of the fuel should be adjusted according to the CO_2 content of the flue gases, which should be 10–12% for bagasse. By pre-heating the air to 300°F. alone, thermal efficiency can be increased by over 12%. Arrangements for forced draught will be necessary and the cost of the extra height of the chimney could be saved.
3. By establishing a scientific control of the installation and various operations involved, most of the losses could be minimised. Efficiency figures with bagasse boilers have reached well over 70%.
4. Molasses—hitherto regarded as a waste product—can be successfully burnt in fire-tube boilers with steam atomizing effecting a saving of nearly 30% of extraneous fuel (coal).

159. Manufacture of soft sugar by using invert syrup from cane-sugar solutions.

S. D. AGNIHOTRI, Kolhapur.

Experiments are undertaken to manufacture soft sugar by using syrup prepared from the Globe Glucose 5A of the Corn Products Co. (India), Ltd. The author compared the soft sugar samples with those

prepared by using the syrups prepared from sulphited clear cane juice, cane syrup and crystal sugar. Syrups were prepared by inverting the solutions with sulphuric acid, neutralizing with calcium carbonate and concentrating under atmospheric pressure. The syrups were a bit coloured. The density of the syrups was 34 and 37 Baume.

Different sugars such as wet third sugar from the centrifugals, sieved sugar and ground sugar were tried, of which the first was found most suitable. The soft sugars obtained by the use of invert syrups were definitely superior to those by the use of Globe Glucose syrups in feel and moisture retaining capacity.

Further work is in progress.

160. Utilization of waste cane molasses. Part I.

S. K. GHOSH *and* R. C. RAY, Patna.

The cane sugar molasses contains a certain amount of nitrogeneous matter (which is present chiefly in a colloidal state) sucrose, reducing sugars, inorganic salts and colouring substance. The latter probably exists in the form of adsorption compounds of the nitrogeneous colloids. It is suggested that molasses can be used for making syrups for drinking purposes and for the preservation of fruits and for preparing artificial honey. The present paper describes experiments for removing colouring matter and the undesirable mineral salts so as to make molasses suitable for the purposes mentioned above.

161. Utilization of waste cane molasses. Part II.

S. K. GHOSH *and* R. C. RAY, Patna.

It is well known that molasses contain a large amount of potassium salts which impart to them a bad taste and render them unfit for consumption by animals. Attempts have been made to recover the potassium salts by the permutite process. The present paper also describes certain experiments carried out with a view to recover the sugars present in the molasses by solvent extraction.

162. Studies on ligno-cellulose.

P. N. SENGUPTA *and* H. K. SEN, Calcutta.

In this investigation the behaviour of lignins obtained from different sources under identical reaction conditions was studied. The sources of the lignins were: (1) *Excoecaria agallocha* (vernacular Gangwa) saw dust, (2) dried water hyacinth, and (3) rice straw. For the extraction, 72% sulphuric acid was used. Lignins were washed completely acid-free. Pure cellulose was also extracted from the same sources by the chlorine peroxide process. The ash contents of the lignins, methoxyl and acetyl groups before and after exhaustive methylation and acetylation were determined. They were nitrated and chlorinated and the soluble and insoluble extracts were examined. These results indicate that under the same conditions the lignins from different sources do not behave identically.

163. Mechanism of the reaction of acetylation.

L. THORIA *and* N. AHMAD, Matunga.

Experiments were carried out in order to determine if a diacetate was formed in the course of acetylation of cellulose, which always results into a triacetate. Acetone solubility was regarded as a test for the presence of diacetate. Work done so far on cellulose swollen with acetic acid shows that a diacetate is formed during the reaction and that it is

considerably increased in quantity, if the following changes are made in the process :—

(*a*) Mercerization of cellulose before swelling with acetic acid.
(*b*) Lowering of reaction temperature.
(*c*) Reduction in the quantity of catalyst.
(*d*) Addition of catalyst to the swelling acetic acid.

It is believed that it might be possible by proper adjustment of the conditions of acetylation to arrest the reaction at a stage when the whole of the reaction product is soluble in acetone. The solution of the problem seems to lie in the following direction :

(i) Diffusion velocity of the reaction mixture should be increased by suitable swelling agents to such an extent that the scene of reaction is shifted completely from the surface of the fibre to the micelle.
(ii) The reaction velocity should be kept at such a low level, as would favour the formation of a diacetate, by adjusting the temperature and the quantity of the catalyst.

164. A note on the fixed oil from *Anona squamosa* (custard apple) seeds.

M. Ghouse Mohiuddin, Hyderabad (Deccan).

The kernel of the fresh seeds (reputed to be a good vermicide or insecticide) on continuous extraction with hot high boiling petroleum ether yielded a pale-yellow semi-viscid, odourless oil, (10%) soluble in ether, acetone, petroleum ether, chloroform, benzene, carbon bisulphide and hot absolute alcohol. Besides the physico-chemical constants—sp. gr., acid number, saponification value, iodine value, Reichert Meissl value, acetyl value, viscosity, refractive index, specific rotation, absorption spectrum, a number of colour reactions have been studied. No alkaloid could be detected in the seeds though leaves have been reported to possess an alkaloid in traces. Further work on the nature of the fatty acids is in progress.

165. A new method of making transparent toilet soap without the use of sugar.

N. G. Chatterji, Cawnpore.

The soap stock is rapidly saponified with stoichiometric quantities of very strong alkali solution and then rectified spirit is added to the hot soap gel to keep the whole in the transparent peptized condition even after cooling.

166. Detergent action of soaps.

B. S. Kulkarni *and* S. K. K. Jatkar, Bangalore.

In continuation of our work on the detergency of the soap solutions, experiments are extended to the series of potassium soaps, with regard to the interfacial tension, deflocculating power, viscosity and emulsifying power of the solutions. Deflocculation experiments with Fuller's earth, as considered along with the other properties of the soap solutions like viscosity and interfacial tension, correspond very closely with the detergent actions of the solutions ; the Fuller's earth may therefore be considered as an ideal dirt in the detergent action of the soaps.

167. Studies in the saponification of oils.

N. G. CHATTERJI *and* R. K. GOBHIL, Cawnpore.

The kinetics of the saponification of *Mohua* oil and the influence of strength of alkali, temperature, rate of stirring, and the original acidity of the oil, on the chemical reaction have been studied in detail. Many interesting results have been obtained, the most important being the extremely rapid and practically complete saponification under certain conditions, of the oil by alkali even when stoichiometric quantities are taken. Attention is drawn to the application of these results in the manufacture of good quality soap.

168. Industrial utilization of the oil from *Pongamia glabra.*

C. R. N. REDDY, Waltair.

Possibilities of utilizing this oil for soap-making and as a lubricant have been investigated. It yields a fairly hard soap with good washing properties comparable with that of cocoanut oil but the lather is close and gummy. Good washing soap is obtained with 25% of oil.

The following constants obtained show that the purified oil is a good lubricant for heavy lathes, gears and chains.

Flash point	400°F.
Pour test	46·4°F.
Viscosity ..	284·36 sec. at 85°F ; 140 sec. at 120°F.
Chemical action	*nil*

It shows no tendency to become gummy as castor oil does.

169. Utilization of oils from roasted cashewnut shells.

N. M. PATEL *and* M. S. PATEL, Bombay.

About 28,000 tons of raw cashewnuts are roasted every year in India for the production of cashewnut kernels. 100 lbs. of nuts give about 40 lbs. of roasted shells containing nearly 18 per cent. oil. These shells are at present thrown away or just burnt. At the present rate of kernel production nearly 11,000 tons of roasted shells which could yield 2,000 tons of oil are available.

The oil from the roasted shells has been extracted by solvent extraction process and its physical and chemical constants have been determined. Drying tests have been carried out. Films with and without the incorporation of driers were prepared on the clean surfaces of glass, copper, tin plate, aluminium, galvanised iron and iron and the time required to dry them at room temperature was determined. The oil was acetylated and the drying properties of the product have been studied.

It has been found that cashewnut oil is not triglyceride of fatty acids but a mixture of a hydroxy acid of the aromatic series and a poly-hydroxy phenol. The rate of drying varies with different surfaces and also varies with temperature. Dry films of ordinary oil were subjected to the action of hot and cold dilute acids, dilute alkalies and dilute alcohol. Dried films of the oil resist the action of cold dilute acids as well as that of hot and cold dilute and concentrated hydrochloric acids. The films are fairly resistant to the action of cold dilute alkalies and alcohol.

The acetylated oil gives films of lighter colour and are affected less by acids and are less resistant to alkalies. The acetylated oil films dry more quickly than ordinary oil. The acetylated oil films resist well the action of dilute and concentrated hot and cold hydrochloric acid.

170. A simple apparatus for the analysis of hydrogen.

S. K. K. JATKAR *and* V. T. ATHAVALE, Bangalore.

A simple apparatus for determining the purity of hydrogen used for hydrogenation of oils is described. The accuracy is 1 part in 10,000.

171. Continuous hydrogenation of oils by catalysts of nickel and its alloys.

V. T. ATHAVALE *and* S. K. K. JATKAR, Bangalore.

The measurements of the activity of the electrolytically oxidized nickel wire showed that its activity is less than that of the supported catalysts like those prepared from Kieselghurcarbonate. Life test of the catalyst showed a stepwise fall in the activity which fell down to 50% in five days. Unlike the Kieselghur catalysts, the wire catalyst has no maxima in activity up to 210. The activity of monel (75 Ni : 25 Cu) wire is equal to that of nickel wire with the advantage that it can be reduced at a lower temperature. The 'ferry' (54 Ni : 46 Cu) has considerably lower activity. Raney catalysts did not give promising results. It was observed that shutting down for a few days always resulted in the disintegration of the catalyst surface. This has been shown to be due to the peculiar property of the various saturated glycerides which show dimorphism, the stable form having markedly lower density.

172. Selective hydrogenation of oil.

S. K. K. JATKAR *and* V. T. ATHAVALE, Bangalore.

Some important observations have been made in the study of hydrogenation of oils in presence of different preparations of nickel catalysts. Each active centre on the catalyst appears to have its own optimum temperature. This is prominently shown by a step out in the temperature coefficient of catalytic activity, and by its own characteristic heat of activation. The question of selectivity of hydrogenation of the different glycerides has been also studied by investigating the curve of iodine value and refractive index, and thiocyanogen value and refractive index, in the course of hydrogenation. Perhaps the most valuable result of this investigation is the vindication of the superior activity of the precipitated catalyst, over other catalysts including those of Lush and Raney; large difference found in commercial practice having been now shown to be due to the change in the method of operation. The precipitated catalyst can now be prepared in a suitable form for commercial purposes and subsequently activated with the same ease as the wire form of catalyst and can be used with existing plants with very little alteration.

173. Continuous hydrogenation of oils by precipitated catalysts.

V. T. ATHAVALE *and* S. K. K. JATKAR, Bangalore.

We have studied the comparative activity of nickel catalysts prepared from (1) precipitated nickel carbonate, (2) nickel carbonate-Kieselghur, (3) nickel hydroxide-silica gel and (4) nickel peroxide-Kieselghur for the hydrogenation of groundnut oil in a continuous process. Although the activity of (1) is the highest, it cannot be used owing to considerable shrinkage on heating. The catalysts, (2) and (4) are far superior to any other catalyst. The preparation of (4) is inconvenient. The life test of catalyst (2) and (4) showed that in the case of (2) there was periodic rise and fall till the activity fell to 85% after continuous run of ten days, while (4) showed a stepwise fall in the activity to 50% in seven days with the same sample of oil.

174. Studies in the oxidation of linseed oil.

N. G. CHATTERJI *and* A. C. GUPTA, Cawnpore.

The rate of oxidation of linseed oil refined in different ways has been directly studied from the rate of absorption of oxygen. The possibility of the application of these results in the paint industry is discussed.

175. Spectrographic studies of ghee.

HABIB HASAN, S. R. BHATE, *and* N. N. INUGANTI, Hyderabad.

Absorption spectra were taken of samples of pure cow and buffalo ghee, adulterated ghee and hydrogenated groundnut oil, characteristic graphs for each will be shown.

176. Supply of ghee in the town of Hyderabad.

S. R. BHATE *and* HABIB HASAN, Hyderabad.

An examination of the supply of ghee in the town of Hyderabad revealed 53% of the samples examined to be adulterated to the extent of 80% and over ; 10% of the samples were adulterated to the extent of 60% and only 27% were found to be genuine. Certain modifications in the methods of examination of ghee samples have been worked out.

177. Chemical examination of the solid residue which separates from the oil of the seeds of *Pongamia Glabra.*

B. L. MANJUNATH *and* A. SEETHARAMIAH, Bangalore.

The solid was repeatedly washed with methyl alcohol in order to remove resinous products. The residue was found to consist principally of Karangin (Beal and Katti, *Chem. Zentrl.*, 1926, II, 596 ; Limaye, *Proc. Ind. Sci. Congress*, 1925, 118), and this could be completely extracted in a soxhlet by boiling alcohol. The residue was found to consist of the zinc salt of behenic acid. This fact is interesting because Sudborough *et al* (*Jour. Ind. Inst. Sci.*, 1923, *6*, 93) during the course of a detailed analysis of the oil were unable to obtain behenic acid.

In addition to those materials, a very small amount of a crystalline body, yellow in colour, was obtained from the alcoholic filtrates.

Karangin is acted upon by light and is rapidly converted into an orange-yellow material. However, this colour disappears on crystallizing the substance from alcohol. But, under certain conditions an orange compound, m.p. 125°, is formed. The nature of this change is under investigation.

178. Some local essential oils.

HABIB HASAN *and* S. R. BHATE, Hyderabad.

The physical constants and chemical constituents of some of the locally found essential oils have been determined. The methods of obtaining them in quantities have been worked out.

179. On sandal seed oil.

P. R. KRISHNASWAMY, M. K. MADHURANATH, *and* B. L. MANJUNATH, Bangalore.

The sandal seed oil has been the subject of several investigations in recent years (Iyer, *Analyst*, 1935, 319 ; Sreenivasaya and Narayana, *Jour. Ind. Inst. Sci.*, 1936, I, 1(A), etc.). The present paper deals with the systematic and complete analysis of the oil.

The seeds contain about 45 per cent. of a thick, viscous oil. On saponification, a large quantity (13 per cent.) of a white, sticky, resinous mass is thrown down.

The liquid acids were found to consist of oleic acid (94 per cent.) and linolenic acid (6 per cent.). The only solid so far isolated is highly unsaturated, and appears to have the formula $C_{18}H_{30}O_2$.

The paper deals with the constitution of this acid.

180. Essential oil from *Spheranthus Indicus*.

(Miss) Mary Mathen *and* B. Sanjiva Rao, Bangalore.

The volatile oil having an agreeable odour was obtained in a yield of 0·3 per cent. from the shrub. It was found to contain α-phellandrene, a bicyclic sesquiterpene and a mixture of tertiary sesquiterpene alcohols belonging to the eudalin group.

181. Paper-pulp fibres of Hyderabad State.

K. Nizamuddin, Hyderabad.

The paper deals with the results of experiments carried out with various raw materials such as bamboos, castor stalks, linseed stalks and kopri grass, etc. found in Hyderabad State.

182. A study of desizing action.

R. B. Forster, M. R. Jambhekar, *and* K. Venkataraman, Bombay.

The use of amylolytic enzymes for the removal of size in cloth 'steeping' prior to kier-boiling and bleaching being common practice in bleachcrofts, an examination of the factors governing the process of desizing has been made. The problem has been approached from two angles: (1) the comparative efficiency of the four main types of products recommended for desizing: (*a*) organic chloro compounds which chlorinate and partially solubilize the starch, (*b*) diastases, (*c*) mould enzymes, and (*d*) bacterial enzymes; and (2) the influence of the constituents of sized cloth and of the conditions of the desizing bath on the degree of desizing achieved.

The course of the starch degradation was followed by noting the reducing power and the viscosity.

The seven commercial desizing agents, chosen as representative of the best known products on the market were first examined with regard to their reducing power.

With a solution of the desizing agent of the order used in mill practice three of the diastases and the bacterial enzyme converted the paste into a clear limpid liquid, while one of the diastases actually increased the viscosity. With regard to saccharifying power, wide variations were noticed among the different agents.

The hydrolysis with the diastase was initially less rapid than with the bacterial enzymes but at the end of 2-3 hours they were equal, the conversion of the starch being nearly complete in the time.

The action of the same enzyme on different starches disclosed that, with the small concentration of enzyme employed, the starches were saccharified to quite different degrees, but the liquefactions as indicated by the viscosities were identical.

Not only is there no advantage in adding any of the common 'wetting agents' to the desizing liquor, but it is definitely detrimental.

Of the metallic salts (e.g. salts of calcium, copper, iron, lead, magnesium, zinc) likely to occur in cotton fibres, all except calcium chloride were found to be unfavourable to the action of the enzyme, several

effecting total inhibition, even in minute concentrations. With the exception of salicylic acid, the common antiseptics in size mixtures were innocuous with regard to the liquefaction of the starch, but the saccharification was in some cases adversely affected. Since coloured goods are desized before boiling and bleaching, the possible deactivation of the amylase by dyestuffs has been studied with a variety of vat and naphthol colours.

The influence of various other factors on the course of desizing is also described.

183. Wetting agents in textile processing. Part I.

D. R. Dhingra, I. S. Uppal, *and* K. Venkataraman, Lahore.

It is well known that the sodium salts of alkyl hydrogen sulphates (e.g. sodium lauryl sulphate) are powerful wetting and emulsifying agents. An improvement has been the preparation of aliphatic compounds in which an amino group condensed with a long chain fatty acid and a sulphonic group attached to a carbon atom are present. Textile auxiliaries with augmented wetting, emulsifying, cleansing and level dyeing properties have now been obtained by the interaction of oleic or ricinoleic acids or their chlorides with sulphanilic or naphthionic acids or their N-alkyl (and particularly the N-methyl) derivatives. The main features of the preparation of these compounds are: (1) the use of ricinoleic acid in which the free hydroxyl group aids the lowering of the interfacial tension between the solution of the substance and fatty matter (such as those present in grey yarn and cloth), and (2) the utilization of sulphanilic and naphthionic acids which are common dyestuff intermediates. The reaction is carried out in general by treatment of the fatty acid chloride with the sulphonic acid of the aromatic amine in a suitable basic solvent such as pyridine; the condensation products are finally converted into the sodium salts. In the case of ricinoleic acid, the hydroxyl group is initially protected by acylation, e.g. by acetylation, the protecting group being removed during the condensation of the acid chloride with the amine or during the later treatment of the product with water or with aqueous acid or during the final conversion into the sodium salt. Other wetting agents are obtained by the further sulphonation of the above oleyl and ricinoleyl amides. Aqueous solutions of these soaps are not precipitated by hard water. The substances are useful in kier-boiling (since they have wetting, emulsifying and detergent properties), as an aid to penetration in mercerization, as additions to the dye-bath leading to level-dyeing (since the substances are protective colloids), as stabilisers for hydrogen peroxide solutions, and as general auxiliaries in textile processing. The magnesium and aluminium salts of the above sulphonic acids are useful, by themselves and in conjunction with sodium silicate or metaphosphate, for stabilising hydrogen peroxide bleach liquors.

184. Injection moulding of shellac compositions.

S. Ranganathan *and* R. W. Aldis, Ranchi.

In the 'Injection Moulding' process, the moulding material is preheated in a closed cylinder and then squirted under pressure into a cold mould. Special advantages of the process are: (*a*) speed of production, (*b*) freedom from 'sticking in the mould' and (*c*) very low rate of mould wear.

A shellac mixture suitable for moulding by the injection process has been formulated and a suitable type of apparatus has been devised.

185. A technical process for washing and refining of stick lac.

A. K. THAKUR, Ranchi.

Seedlacs as prepared in India often have adhering oxidised lac-dye and nitrogenous matter, both of which react deleteriously in the application and processing of such seedlacs. The consumer of lac requires 100% resin in his lac products, for otherwise the materials behave erratically more especially when used in protective coatings and in electrical insulation. A technical method has been worked out, by which the impurities in the crude material can be eliminated. It consists of :—

(1) grinding slowly the stick lac in a ball-mill in presence of dilute solutions of potash alum or tri-ethanolamine or other suitable reagents, which help to dissolve the dye and other soluble matter. They are removed by repeated process of decantation, leaving washed resin in the mill.

(2) The powdered lac is further purified by immersing in saturated solution of sodium chloride. The lac resin floats on the surface while the impurities settle at the bottom. This is very efficiently accomplished by means of 'Sharple's Super Centrifuge'.

186. Estimation of orpiment in shellac.

M. RANGASWAMI, Ranchi.

A method for estimating the orpiment content of shellac has been published by this Institute (Bulletin No. 7 Indian Lac Research Institute, 1932, p. 2). The methods generally in vogue take long time and the use of large quantities of shellac for digestion with fuming acids evolving large volume of fumes. The possibility of using smaller quantities of samples and thus shortening the time required for an analysis without detracting from accuracy, has been investigated.

Careful mixing and fine grinding before sampling are necessary for accurate results. The usual iodometric method with N/50 or N/100 iodine solution is followed. An apparatus for digesting several flasks at a time has been devised, in which the use of suction can be obviated, and the fumes adsorbed.

	Found percentage of As_2S_3
Modified American method as followed by the Indian Lac Research Institute, using 10 gms. of shellac ..	0·92, 0·91, 0·91.
The present method using 0·5 gm. of shellac	0·94, 0·91.
The present method using 1·0 gm. of shellac	0·89, 0·90, 0·89, 0·91, 0·94.

187. A new method for the iodine value of shellac.

M. VENUGOPALAN *and* H. K. SEN, Ranchi.

The iodine value of shellac is used to estimate the resin content. In America the method of Wij's has been adopted as standard. This method is not entirely satisfactory, and one of the objections to the method lies in the difficulties associated with the preparation of the Wij's reagent which is also rather tedious. A means of overcoming the difficulties of preparation of the reagent has been indicated by Hunter and Hyde ('The Analyst' LVIII, No. 690, p. 523, 1933). These authors use equivalent amount of potassium iodide and toluene-*p*-sulphondichloramide dissolved in glacial acetic acid.

In this laboratory, the action of *p*-tolyl-iodochloride dissolved in acetic acid on shellac has been investigated with a view to develop a 'chlorine value' of shellac. This method gives results of the same order as by the Wij's method, and it has also been extended to certain oils.

188. Separation of aleuritic acid from shellac.

N. N. MURTI, R. W. ALDIS, *and* A. K. THAKUR, Ranchi.

Aleuritic acid is the largest constituent of the mixture of hydroxy acids which go to form shellac (Harfies and Nagel *Wiss. Veroff. Siemens-Konzern 1*, part 3, pp. 178–181). Its constitution has been established as trihydroxy palmitic a cid, and the disposition of the hydroxyl groups are shown as below :—

$$CH_2OH\,.\,(CH_2)_5\,.\,CH\,.\,OH\,.\,CHOH\,.\,(CH_2)_7\ COOH.$$

The possibility of utilizing this acid in the manufacture of synthetic resins, in medicine and as a means of modifying shellac by increasing the aleuritic acid content has been indicated, and accordingly methods for quickly and cheaply isolating this constituent of shellac have been investigated.

Amongst the new methods which have been evolved, the following are promising: (*a*) mild oxidation, to break down the unsaturated acids leaving the aleuritic acid in a comparatively free condition ; (*b*) fractional solubility of the hydrolysed shellac acids ; and (*c*) 'salting-out' by addition of sodium chloride to a solution of shellac in 5N-caustic alkali. In all instances, aleuritic acid of good purity and yield is obtained.

189. Preparation of 'hard lac resin'.

M. VENUGOPALAN *and* H. K. SEN, Ranchi.

Shellac from which the soft, ether-soluble resin has been removed shows improved properties for certain uses. Methods for preparing this resin which avoid the expensive and troublesome process of direct ether extraction are being investigated. Verman and Bhattacharya (Tech. Paper No. 1, 1934, London Shellac Research Bureau) have published a toluene extraction method which retains 10–15% of the soft resin, but which is reported to be quite satisfactory for the purposes for which this hard resin is used. Our object has been to separate the hard resin in a much purer condition : (*a*) by the reaction of urea with an acetone solution of shellac, which polymerizes the hard resin, leaving the soft resin in a condition easily extractable by acetone. This process removes the soft resin practically completely without affecting the hard resin which is now polymerized. The polymerized hard resin can be easily depolymerized by boiling with water which also removes the urea. (*b*) A second method has also given promise which consists in precipitating the hard resin from an acetone solution of shellac by dropping it on ether and vigorous stirring. The precipitated hard resin is washed once or twice with ether, and the mixed solvents are used in a counter-current for further precipitation. The solvents are ultimately recovered by fractionation. The hard resin in this instance is not polymerised. Properties of so separated hard resins are being studied.

190. Possibility of production of nicotine and its salts from tobacco waste in the Bombay Presidency.

V. C. AMIN *and* M. S. PATEL, Bombay.

Large quantities of tobacco waste are available in tobacco producing districts of the Bombay Presidency, especially in the District of Belgaum. It is estimated that about 200 to 300 tons of tobacco waste are available

in that district alone. A process for commercial production of nicotine suitable to local conditions has been worked out. It has been found that it is possible to prepare crude nicotine and nicotine sulphate at a very reasonable cost. The product has been found satisfactory by some of the importers of nicotine and nicotine products in the United Kingdom. In the beginning a large portion of the production will have to be exported and only a part can be utilized in this country. As the use of nicotine and nicotine salts for insecticidal purposes becomes popular in this country it is hoped that all the production of the proposed plant treating about ½ ton of tobacco waste per day would be consumed locally.

Fatty acid salts of nicotine such as nicotine stearate, oleate and nicotine salts of fatty acids from groundnut oil, linseed oil and castor oil have been prepared. Their physical, chemical and bactericidal properties have been studied.

191. Low temperature distillation of coal and heavy tar.

K. L. Ray, B. C. Guha, *and* H. K. Sen, Calcutta.

Recent investigations show that the distillation of coal and tar oil mixtures considerably increases the yield of light oil (*Industrial and Engineering Chem.*, June 1936), but as yet no commercial plants for this have been constructed. In all these samples of coal, the percentage of ash is substantially lower than that of an average second class Indian coal. The present work has for its object the caking of non-coking coals, and a study of the volatile products of coal-tar oil distillation under low temperature conditions. The yield of tar, after deducting the probable contribution of the added tar, is found in most cases to be between 65 and 75 gallons per ton of coal of which the ash content is between 17 and 19%. The tar when fractionated, yields :

11 gallons of light oil boiling up to 170°C.
35·8 ,, ,, middle ,, ,, ,, 230°C.
24 ,, ,, heavy ,, ,, ,, 360°C.
Pitch – approximately 11% of the weight of tar.
The gas analysed :
CO_2, 2·8% ; O_2 nil; C_2H_4 4·0% ; CO, 6·5% ; H_2, 39·3% ; CH_4, 43·0% ; N_2, 4·4%.

192. The destructive distillation of groundnut shells.

G. Rama Rao, Hyderabad (Deccan).

Groundnut shells are obtainable in abundance in the Hyderabad State. This work was undertaken to examine the suitability of commercial production of methyl alcohol, acetic acid and combustible gases from these. The thermal decomposition has been studied with special reference to the rate of evolution of the gases, their volumetric composition and calorific value. It has been found that the volume of combustible gases is more and has a higher calorific value than that obtained in the dry distillation of wood. The yields of acetic acid and methyl alcohol in the pyroligenous acid compare favourably with those from the dry distillation of wood besides containing some ammonia.

193. Carbonization assays of Indian coals.

M. R. Mandlekar, Bangalore.

With a view to ascertain the different properties of coals which would determine the suitability of the material for special industries, e.g. glass manufacture, metallurgical operations, gas industry, etc. an investigation into the carbonization assays of Indian coals has been commenced.

194. Gas making from cheaper grades of fuel oils.

G. Rama Rao, Hyderabad (Deccan).

This paper deals with the cracking of Borneo Diesel oil and crude oil in a Mansfield gas producer. The rate of evolution of the gas, the rate of consumption of oil and the calorific value of the gas have been studied. The tar has been fractionated with a view to find useful products.

195. The cleaning of power station flue gases with particular application to Hyderabad State power station.

W. E. J. Beeching, Hyderabad (Deccan).

Of the many systems for cleaning power station gases, the best known are the dry and the wet systems. The former consists of cyclones cleaning by centrifugal force, and electrostatic precipitators which pass the gases through an electrostatic field between two sets of electrodes. The wet systems involve water films, water sprays or a combination of both ; these remove the dust, and also dissolve the sulphur.

Hyderabad power station has a pulverized fuel firing which rules out dry cleaning. A standard wet system, involving considerable structural alterations would have been very costly. Investigations made to find a cheaper solution showed that in the presence of coke the water required was much less for the absorption of SO_2. Highly aerated wash water, preferably above 160°F. the presence of manganese, or iron as catalysts oxidizes the SO_2 to the highly soluble SO_3.

An experimental plant of two interconnected large cylinders, both fitted with water sprays, and shelves of coke in the second, was constructed ; practically all the dirt was removed, and acid trickled down the inside of the second cylinder.

The acidic effluent can be suitably treated to obtain either calcium bisulphite for paper mill requirements or sodium sulphite for the wood pulp industry.

Bio-chemistry

196. The synthesis of vitamin C by germinating seeds.

B. N. Ghosh *and* B. C. Guha, Calcutta.

Germinating *kanchamung*, *mator*, *barboti*, *chhola* have been investigated in relation to their power to synthesize vitamin C from mannose at different hydrogen ion concentrations. There are very great differences in the behaviour of the different seeds in this respect.

197. On ascorbigen.

B. C. Guha *and* J. C. Pal, Calcutta.

Practically conclusive evidence has been obtained to show that part of the ascorbic acid present in many vegetable foodstuffs is present in a combined form, from which the free vitamin can be released by heating with water. This combined ascorbic acid has been called ' ascorbigen '. It has been possible to extract ascorbigen from cabbage free from ascorbic acid. Further investigations are proceeding as to its isolation and properties.

198. Some properties of ascorbigen.

P. N. Sen Gupta *and* B. C. Guha, Calcutta.

Working with cabbage, various solvents have been tried for extracting ascorbigen free from ascorbic acid. Processes have been discovered by which a considerable concentration of ascorbigen has been effected.

199. The distribution of ascorbic acid oxidase in plant and animal tissues.

R. K. Chakraborty *and* B. C. Guha, Calcutta.

In an attempt to study the properties of the enzyme, ascorbic acid oxidase, a preliminary survey has been made of the oxidase content of many plant animal tissues. In general, the animal tissues investigated including the liver and kidney tissues of the cow, guinea-pig, rabbit, fish and fowl, appear to contain practically no ascorbic acid oxidase. Among the vegetable food-stuffs studied, sasha (cucumber) appears to be the richest source of the enzyme, while many common Indian fruits like pine-apple, mango, guava, etc. seem to be practically free from it.

200. The nature of sweet potato amylase.

K. V. Giri, Bangalore.

Sweet potato amylase behaves like a pure β-amylase in the hydrolysis of amylo-amylase. The amylase hydrolyses a portion of starch, leaving a residual material which gives violet colour with iodine. This residual material is hydrolysed by β-amylase with great difficulty, while the α-amylase of malt hydrolyses it in such a way that the colouration with iodine disappears at a low maltose level. The hydrolysis of amylo-amylase by sweet potato amylase is followed by decrease in the intensity of blue colour, thereby showing that β-amylase attacks those groups in the starch molecule which are responsible for the blue colour with iodine. The bearing of these results on the recent developments in the constitution of starch is discussed in detail.

201. Magnesium activation of tissue phosphatases.

K. V. Giri *and* N. C. Datta, Bangalore.

The susceptibility of the phosphatases of liver, kidney brain and bone to activation by magnesium has been studied in detail in relation to their purity, method of preparation and age. The results indicate that the degree of activation is very much enhanced on ultrafiltration. In some cases it was found that the phosphate of the crude extracts was not activated by magnesium, while the same extracts on ultrafiltration were found to respond to magnesium activation to a considerable degree. It is concluded from the results that the susceptibility to activation by magnesium depends on the complexity of the enzyme colloid, and the presence of concomitant substances present in the extract. A method of determining the true value of the phosphatase activity in tissues has been suggested.

202. Plant phosphatases.

K. V. Giri, Bangalore.

The phosphatase from sprouted soya bean. A highly active preparation of phosphatase from sprouted soya bean has been obtained by purification of the crude aqueous extracts of the germinated seed powder. The method consists of (*a*) fractional precipitation with alcohol or acetone, (*b*) solution of the most highly active fraction, (*c*) precipitation of the impurities at pH 5·0, and (*d*) final dialysis or ultrafiltration. A very active preparation was obtained, whose activity was about 102 Ph.P.E./mg. For glycerophosphate hydrolysis and about 210 Ph.P.E./mg. for pyro-phosphate hydrolysis. The preparation is about 350 times as active as that of the original sprouted seed powder. It gives protein and carbo-hydrate reactions. The behaviour of the purified enzyme under different conditions of temperature, pH, its specificity towards various phosphoric

esters and its activity in presence of various salts has been studied in detail. The relation between the activity of the phosphatase and vitamin C in association with metals like Cu has also been studied.

Soluble and insoluble phosphatases in cereals. In continuation of previous work (*Proc. Ind. Sci. Cong.*, 1936, p. 57) the state of phosphatases occurring in seeds and their changes during the germination of seeds has been further investigated. It has been found that in soya bean the phosphatase is partly soluble and can be extracted with water. On treatment with acetone and ether in order to remove the fat, the adsorbed phosphatase is rendered soluble, thereby showing that a part of the enzyme is probably adsorbed to the fat contained in the seed, which renders it insoluble. Similar studies have been made with other cereals, and it is suggested that in oil seeds, protein rich seeds and starch containing seeds, the enzyme is partly adsorbed to the fat, protein and starch respectively, and that different methods of extraction have to be tried, depending on the nature of the seed, in order to bring the phosphatase into a soluble and active state.

Glycero- and pyrophosphatase systems in plants and animal tissues. From a study of several plant materials and animal tissues it has been found that the ratio :—

pyrophosphate P : glycerophosphate P

is greater than 1 in the case of plant extracts and less than 1 in the case of animal tissues, when the enzyme is allowed to act on the respective substrates and the inorganic P liberated is determined. This difference in the properties of the phosphatase systems of plants and animals may be applied to cases where the origin of the phosphatase has to be determined.

203. A micro method for the determination of phosphatase activity in biological fluids.

V. Ranganathan, Bangalore.

The release of inorganic phosphate from glycerophosphate when it is hydrolysed by phosphatase can be measured by the increase in conductivity of the solution. This property has been applied to the determination of the activity of phosphatases in blood and other tissues under standard conditions of termperature and pH. It has been found that this affords a very convenient method for measuring the changes in the activity of the phosphatase in blood, which sometimes varies with the different types of disease. The method is considered, therefore, to be of value in the diagnosis of diseases like rickets which affect the phosphatase activity of blood. By this method very small quantities such as 10^{-2} milligrammes of phosphorus can be very accurately determined. Further work is in progress in this direction.

204. The amylase system of rice grain during ripening and germination.

K. V. Giri *and* A. Sreenivasan, Bangalore.

In the resting rice grain a large part of the amylase is in an adsorbed condition and is therefore not extracted with water. Phosphate buffer extraction at pH 7 produces a considerable increase in the amylolytic power of the rice grain, both in the saccharifying and in the dextrinising functions. Resting rice grain contains two amylases with different pH optima. The amylase of optimum pH 4·6 behaves like pure β-amylase, while that of optimum pH 7 behaves like pure α-amylase in their hydrolysis of amyloamylose. The two amylases are present in a highly active state in the rice grain at milk stage, but become gradually inactive with the advance in ripening until in the fully ripened grain, they exist in such a condition that they cannot be extracted with water. During germination on the other hand, the amylases increase in activity. The

pure α and β amylases of resting rice grains are each converted into an amylase system ($\alpha+\beta$) characteristic of malt on germination.

During the ripening of the rice grain, the activity of the phosphatase decreases with the advance in ripening. There is also a corresponding decrease in the inorganic phosphate content of the grain and increase in the phytin phosphorus. During germination the reverse of the above happens, viz. an increase in the activity of the phosphatase and in the inorganic phosphorus and a decrease in the organic phosphorus. It is suggested that the phosphate formed as a result of phytin hydrolysis during germination serves to elute the amylases which are otherwise present in a dormant condition and thus render them active.

The bearing of the results on the problem of amylolytic changes during the ripening and germination of cereals is discussed. Work relating to the distribution of the two amylases in the different parts of the rice grain and their changes during the storage of freshly harvested paddy is in progress. This work is being extended to other cereals as well.

205. Extraction and chemical analysis of the proteins of green gram and lentil.

K. P. Basu, M. C. Nath, *and* M. O. Ghani, Dacca.

Green gram (Phaseolus Mungo) and lentil (Lens Esculenta) have got almost the same percentage composition (protein content of the first being 23·20% and that of the latter 22·60%).

Percentage of total nitrogen extractible by different solvents in both cases is 92·3.

In case of green gram the maximum amount of protein is extracted by 3% salt solution while 2·5% salt is the best concentration for lentil.

As many as seven different proteins have been isolated from green gram, but only three in case of lentil. It was not possible to obtain the water soluble protein of lentil, in pure condition.

Elementary composition of the isolated proteins have been found by microanalysis and nitrogen distribution of the proteins (as different amino acids) has been made by the method of Van Slyke as modified by Plimmer and Rosedale.

Proteins in lentil are markedly deficient in cystine, which might account for the lower biological values obtained with this pulse and also might easily explain the loss of fur, observed in the long period feeding experiments.

Lentil contains a smaller percentage of histidine (an essential amino acid) than the green gram; but both arginine and lysine contents of lentil are higher than those of green gram.

Auto-hydrolysis of proteins in lentil is less than those in green gram and is therefore not the cause of the presence of such a large amount of non-protein nitrogen in the former.

206. Extraction and chemical analysis of proteins of Lathyrus Sativus.

K. P. Basu *and* R. Mukherjee, Dacca.

Water extracts 45·2%, sodium chloride 36·2%, alcohol 1·2% and 0·2% alkali 11% of the total proteins of Lathyrus Sativus. The proteins have been analysed by the Van Slyke method and tyrosine, tryptophane and cystin have been estimated colorimetrically. The proteins appear to be deficient in tryptophane. Daily addition of tryptophane to young rats on Lathyrus Sativus diet restored the healthy appearance of rats and silkiness and smoothness of fur but no enhancement of growth was observed.

207. Extraction and chemical analysis of proteins of aus and aman rice.

K. P. BASU *and* M. N. BASAK, Dacca.

1. From aman rice (Bhashamanik), water extracts 5·8%; salt 22·6%; 75% alcohol 3·7%; and alkali 62·7% of the proteins; the corresponding values for aus rice are 7·5%, 29·2%, 3·0% and 55·7% respectively.
2. Aus and aman rice globulin and glutelin have been extracted and analysed by the Van Slyke method. Tyrosine and tryptophane contents of these proteins were determined by colorimetric method.
3. Aman rice contains more sulphur containing amino-acid and more arginine than aus rice.
4. Additions of either cystine or methionine in equivalent amounts cause growth in rats on aus rice diet (protein content 5%), which in its absence is incapable of promoting any growth. It is suggested that the sulphur containing amino acid requirement for growth is higher than that for maintenance.

208. Determination of nitrogen in pulses.

A. SREENIVASAN *and* V. SADASIVAN, Bangalore.

In the determination of total nitrogen in pulses (like *Glycine hispida, Pisum sativum, Cicer arietinum, Phaseolus mungo Dolichoo lablab,* etc.) by the Kjeldhal method, it has been observed that highly inconsistent and usually low values are obtained when the digestion is stopped soon after the mixture begins to clear. Accurate and concordant results are obtained only when the digestion is continued for some time after the stage of clearance. Soaking with water prior to commencement of digestion considerably hastens the progress of digestion and often in such cases correct values are obtained when the digestion is stopped soon after the mixture clears. Germinated pulses digest also quicker and correct values are obtained in such cases by 'dry' digestion with sulphuric acid even when the digestion is stopped at clearance stage. It is suggested that germination or boiling with dilute sulphuric acid results in a partial breakdown of the protein compounds into more easily decomposable substances.

With peas, however, the germinated seeds give higher values for total nitrogen than the ungerminated ones. Work is in progress to determine whether or not this increased nitrogen content of germinated pea seeds is due to any nitrogen fixation.

209. Detection of adulteration of cereal flours by the 'agar plate' method.

P. N. BHARGAVA *and* K. V. GIRI, Bangalore.

The method (*Science*, 1935, *81*, 343) previously developed for the differentiation of pure starches, has been extended for the differentiation of cereal flours, and their detection when present in mixtures. The cereal flours have been classified into groups according to their characteristic coloured diffusion zones developed when a drop of amylase solution has been allowed to diffuse through an agar plate impregnated with the boiled extract of the flour, and finally flooded with iodine. The method has been successfully applied to the detection of rice flour in wheat flour. It has been found possible to judge easily to the nearest 20 per cent. of rice in a given mixture. The method has also been applied to the detection of adulteration of rice with maize; admixture of ragi with wheat or maize, barley with wheat, jowar with rice, etc. The method is particularly

useful when the material is cooked, in which case there is no method available for the detection of adulteration.

210. On the use of some new reagents in macro- and micro-analysis—a review.

P. Ray, Calcutta.

Within the last few years we have studied some organic compounds for use as analytical reagents, and three of these have been found very useful. These are rubeanic acid, quinaldinic acid and dimercapto-thiobiazole.

Rubeanic acid or dithio-oxamide, which may exist in a tautomeric thiol form, reacts with copper, nickel and cobalt ion to give intensely coloured insoluble precipitates. The substance has been placed on the market as reagent for the above metals. As the colour of the precipitate differs for different metals, the reagent can be employed to detect these metals in presence of one another by means of spot tests. It has also been employed for the detection of ruthenium, palladium and platinum (Wolbling and Steiger, *Mikrochem.*, *15*, 295, 1934).

The colour of the precipitate given by different metals with rubeanic acid is as follows:—Copper-greenish black, nickel-blue, cobalt-brown, ruthenium-blue, palladium-fire-red, platinum-brownish red.

Quinaldinic acid or quinoline-carboxylic acid gives a quantitative precipitation of copper from mineral acid solution, of cadmium and ferrous iron from neutral solution, and of zinc from acetic acid and slightly ammoniacal solution.

The acid has been utilized with excellent results for the estimation of copper in the presence of all other metals excepting zinc. The presence of even phosphoric and arsenic acids does not interfere.

Equally good results have been obtained in the estimation of zinc in acetic acid solution whereby it can be separated from manganese, phosphoric acid, arsenic acid, calcium, strontium, barium, magnesium and alkali metals. In ammoniacal solution containing tartaric acid, zinc can be estimated with this reagent in presence of iron, aluminium, uranium, beryllium and titanium.

Cadmium has also been estimated as cadmium quinaldinate in neutral solution.

Colorimetric estimation of Fe ion has also been effected with the reagent with good results. A violet colour is developed in presence of traces of ferrous iron.

The precipitates of copper, zinc and cadmium can be directly weighed.

The reagent has been used with quite satisfactory results for the micro-estimation of copper and zinc.

Dimercapto-thiobiazole has been found to give coloured precipitates with most of the metals of the second analytical group. Of these the copper compound is most insoluble. Bismuth and lead compounds come next in order.

Copper can be separated in mineral acid solution, or under suitable conditions, from As, Sb, Sn, Mo, W, Fe, Zn and all metals of the group three (analytical) and the succeeding ones.

Lead has been separated from As, Sb, Sn, Mo and alkaline earths in presence of tartaric acid and alkali fluoride.

Bismuth gives a bright scarlet-red precipitate, which is highly characteristic. It can be used as a very sensitive test for the micro-detection of bismuth in presence of all other metals except copper. The interfering action of lead, arsenic, antimony, tin and mercury can be eliminated by the addition of alkali fluoride. This reaction with bismuth was also studied by Dubsky and Okac (*Zeit anal. Chem.*, *96*, 267, 1934).

The dithiol precipitates cannot be weighed directly, and hence the reagent is used for the purpose of separation only.

211. Oxidation-reduction potential of sulphydrill bodies, ascorbic acid and other systems of biological interest —a review.

J. C. GHOSH *and* T. L. RAMACHAR, Dacca.

Oxidation-reduction processes are now interpreted in terms of electron transfer, and the free energy of such migration can be expressed in terms of electrode-potentials. If the oxidation or rather dehydrogenation of glutathione and ascorbic acid are reversible processes, as given by the equations below

$$2\ GSH \rightleftarrows GSSG + 2H^{+} + 2e$$

$$\text{Ascorbic} \rightleftarrows \text{Dehydroascorbic acid} + 2H^{+} + 2e$$

the electrode potentials of these systems on an inert metal surface should be given respectively by the equations

$$E_h = E_0 - \frac{RT}{F} P_H + \frac{RT}{F} \log \frac{[\sqrt{GSSG}]}{[GSH]} \text{ for glutathione system} \ldots\ldots (1)$$

and

$$E_h = E_0 - \frac{RT}{F} P_H + \frac{RT}{2F} \log \frac{[\text{Dehydroascorbic acid}]}{[\text{Ascorbic acid}]} \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Dixon and Quastel, Michaelis, Flexner, Barron etc. following ordinary procedure found that the potential of sulphydrill compounds is given by the empirical equation :

$$E_h = E_0 - \frac{RT}{F} P_H + \frac{RT}{F} \log \frac{1}{[GSH]}$$

and for ascorbic acid Green found that the potential is still less susceptible to thermodynamic treatment and is expressed by the equation :

$$E_h = +\cdot 375 - \cdot 060\ P_H$$

The cause of these anomalous behaviour has been traced to the film of oxygen or oxide which is present on even noble metal surfaces and which in the case of mercury cannot be removed by long continued evacuation. A new experimental technique has been developed according to which this oxygen film tenaciously adhering to the surface of electrode metals was removed by cathodic discharge of hydrogen, which simultaneously reduced the oxidant present in the solution bathing the electrode. After electrolysis a stream of pure nitrogen was bubbled through the solution for a few hours and the steady value of the potential of the electrode, which functioned as a cathode during electrolysis, was measured. The electrode potentials have been found to be in agreement with the thermodynamic equations (1) and (2). Investigations on the electrode potential of lactic-pyruvic acid systems by means of the above technique are in progress.

212. Initiation of chemical reactivity under electrical stimulation—a review.

S. S. JOSHI, Benares.

Data are given for a chemical change in N_2O, NO, NO_2, SO_2, SO_3, PH_3, H_2O, H_2O_2, H_2Cl_2, benzene, wax paraffins, H_2S, $CaCl_2$ both when pure, and in the presence of foreign gases and different electrical and working conditions. A review of work on the kinetics of chemical change under different types of electrical discharges, exposure to α-rays, short wave and heat radiations has been made with a view to obtain points of contact and similarity of mechanism. A theory for the velocity of the chemical reactions under the electrical discharge has been developed on the basis of the fractional time of a period characteristic of a given

A.C. supply. The after-effects of this electrical activation proceed markedly differently from those observed, especially in thermal activation. Reaction chains are set up along the trajectory of the moving ion, for which a quantitative explanation is given on the basis of the above theory (*cf.* also Elliott, Joshi and Lunt, *Trans. Farad. Soc.*, 1927, *23*, 57). Furthermore, the course of a change produced electrically may be more complex than its thermal or photochemical analogue. Determination of the ionization current flowing through the reaction space has been found to be a sensitive indicator of the course of the reaction, even where the change involved is only physical or quasi-chemical. Wall catalysis has been found to be an appreciable factor in the electrical as in other types of activation. An observation has been made, capable of wide application, that the conditions characteristic of the occurrence of a chemical change by electrical activation are best explored by means of a quantity designated the 'threshold potential', which resembles, but is different from the Paschen potential. In terms of this, it is possible to investigate a variety of catalytic and allied influences on the initial atom and the mechanism of the 'main' reaction. An evaluation of this quantity, not studied quantitatively hitherto in the literature of the subject, has been found to be of much utility in explaining the observed variations in the current, dissipation of energy in the system, the power factor and the fractional voltage on the reaction space during the progress of a given reaction.

213. The alkaloids of *Holarrhena antidysenterica*—a review.

S. SIDDIQUI, Delhi.

After a brief reference to the history and uses of *Holarrhena antidysenterica* and the work done on its alkaloids from 1858 to 1930, the paper would deal in detail with the entire work on the subject carried out since, by me and my co-workers. This work extends in two directions:

1. The isolation of eight subsidiary alkaloids of conessine and the fixing up of their interrelationship, chiefly through the methylation of some of them to conessine and the N-demethylation of conessine to two of its subsidiary bases. In this connection, would also be discussed the claims of several other alkaloids, isolated by various authors (Ghosh and Bose, *Archiv, and Pharm.*, 1932, *270*, 100; Haworth, *J.* 1932 631; Bertho, Schuckmann and Schonberger, *Ber.*, *66*, 786, 1932; Peacock and Chaudhri, *J.* 1935, 734) during this period, to be considered as uniform products.
2. Studies in the conessine series, involving its isomerization and oxidation and also the investigation into the relationship between the comparative N-stability of conessine and *iso*-conessine on the one hand and their respective pharmacological activity on the other.

Most of the work outlined above has already appeared in eight publications (*J. Ind. Chem. Soc.*, 1932, 553; 1933, 673; 1934, 283; 786; *Proc. Ind. Acad. Sci.*, 1935, A, 2–426; 1936, A, 3–249; 1936, A, 3–257; 1936; 1936, 3. A). Some of it however is still unpublished and this includes the degradation of conessine and *iso*-conessine to a common hydrocarbon indicating the nature of relationship between the two bases.

The paper would also deal with the improved methods of isolating the chief alkaloid, conessine, with a view to its industrial exploitation.

214. Nitrogen transformations in the soil—a review.

N. R. DHAR, S. K. MUKERJI, E. V. SESHACHARYULU, *and* S. P. TANDON, Allahabad.

Nitrogen fixation by the addition of molasses to soil in fields.

Nitrogen fixation in the induced and catalytic oxidation of glucose or canesugar.

Nitrogen fixation in the oxidation of molasses mixed with soil.
Azotobacter fixes nitrogen very well in Tropical soils.
Composts made with molasses when added to soil in heaps.
Nitrogen fixation in the photo-oxidation of canesugar mixed with sterilized soil in quartz vessels.
Nitrogen fixation and azotobactercount on the application of molasses, carbohydrates, starch and glycerol to soil.
The probable mechanism of nitrogen fixation.
No denitrification takes place on the addition of molasses to fields.
Fixation of nitrogen in the oxidation of cellulosic substances mixed with soil.
Nitrogen fixation in the oxidation of sodium salts of organic acids.
Influence of light on nitrification and ammonification.
Photo-oxidation of nitrite to nitrate.
Influence of temperature on the bacterial nitrification.
Influence of temperature on the ammonification of urea.
Influence of temperature on the nitrogen fixation by Azotobacter.
Available nitrogen in Tropical soils.
Significance of carbon-nitrogen ratio in soil.
Influence of temperature on the carbon-nitrogen ratio in soils.
Loss of nitrogen from soils and its retardation.
Decomposition of solutions of ammonium nitrite.
Decomposition of mixture of ammonium sulphate and potassium nitrite mixed with dry soil.
Nitrogen loss from mixtures of alanine and potassium nitrite mixed with soil.
Nitrogen loss by exposing to sunlight, ammonium salt and nitrite solution mixed with soil under sterile condition.
Part played by organic manures.
Influence of sunlight in the nitrification and denitrification of ammonium sulphate added to fields.
Retardation of nitrogen loss from field soils by the addition of molasses.
Molasses and press mud in reclamation of alkali land.
Vast tracts of land in India are alkaline.
Defects of alkali lands.

215. The detection and estimation of degradation in cotton—a review.

R. B. Forster *and* K. Venkataraman, Bombay.

Following a brief review of the physical and chemical evidence on which the accepted structure of cellulose is based, its implications in textile processing are discussed. The objective of the bleacher is to produce as near an approximation to 'standard' cellulose as possible; deviations from this ideal may be followed quantitatively by determinations of (*a*) the moisture content, (*b*) the ash and ash alkalinity, (*c*) reducing power ('copper number'), (*d*) fluidity in cuprammonium solution, (*e*) absorption of methylene blue, and (*f*) strength tests. The moisture content may be conveniently estimated by distilling the cotton with xylene or dioxane, leading the distillate into acetic anhydride and analysing the acetic acid-anhydride mixture. A rapid method for determining the reducing power, which may also give an insight into the nature of the degradation, is to extract the cotton with standard caustic soda solution, neutralize with standard acid and titrate with ceric sulphate solution. The affinity of oxycellulose for metallic ions at present provides the only method available for differentiating it from hydrocellulose, i.e. for distinguishing excessive bleaching from excessive souring. A more satisfactory test and a method of estimating the relationship of the reducing power of a

sample of cotton to its aldehydic and carboxylic contents are desirable. Preliminary experiments in this direction are described.

216. Thermal decomposition of mercurous nitrate.

M. S. SHAH *and* B. G. JOSHI, Ahmedabad.

In continuation of the previous work (*Proc. Ind. Sci. Cong.*, 1935, P. 174), the authors have studied the decomposition of mercurous nitrate in detail by heating the substance in vacuo at various temperatures and analysing quantitatively the solid and gaseous products of the decomposition. Two series of experiments were performed : in the first series, the gaseous products were removed by evacuating the system at the temperature of experiment, while in the other series, evacuation was carried out at room temperature after allowing the gaseous products to be absorbed by the solid product of the decomposition for a period of 12 hours.

The results of the above experiments together with the observations recorded before (*loc. cit.*) show that mercurous nitrate decomposes primarily into mercuric oxide and nitrogen tetroxide, as

$$HgNO_3 \rightarrow HgO + NO_2 \quad \ldots.(1)$$

Some nitrogen tetroxide produced in (1) oxidises undecomposed mercurous nitrate to mercuric nitrate with the evolution of nitric oxide, as

$$HgNO_3 + 2\,NO_2 \rightarrow Hg(NO_3)_2 + NO \ldots\ldots..(2).$$

The mercuric nitrate so formed in (2) undergoes decomposition above 200° as shown in the following abstract, the ultimate product of decomposition being a scarlet red oxide of mercury.

When the gaseous products of the decomposition are allowed to be absorbed at room temperature by the solid product of decomposition, nitric oxide is left unabsorbed in the gaseous state while nitrogen tetroxide is absorbed by mercuric oxide, probably with the formation of mercuric nitrite and mercuric nitrate.

217. Thermal decomposition of mercuric nitrate.

M. S. SHAH *and* B. G. JOSHI, Ahmedabad.

The decomposition of mercuric nitrate has been studied by heating the substance in vacuo at 100°, 150°, 200° ... 300°, and examining the solid and gaseous products of the decomposition.

The decomposition which is very slow at 100°, becomes rapid above 200° and is practically over at about 300°, and can be represented as

$$2\,Hg(NO_3)_2 \rightarrow 2\,HgO + 4NO_2 + O_2.$$

218. Interaction between mercury and nitrogen tetroxide : Isolation of nitro-mercury.

M. S. SHAH *and* B. G. JOSHI, Ahmedabad.

The action of (i) gaseous and (ii) liquid nitrogen tetroxide on mercury has been studied by conducting experiments with varying amounts of mercury and nitrogen tetroxide in vacuo at 25° and −8° respectively and analysing the solid and gaseous products of the interaction at room temperature. In both cases, the reaction starts with the evolution of nitric oxide and the formation of greyish black substance. With liquid nitrogen tetroxide, the reaction is rapid and the greyish black substance is immediately converted into mercurous nitrate, whereas with gaseous nitrogen tetroxide, the reaction being slow, the formation of mercurous nitrate is observed only on its surface.

If by constant shaking a fresh surface of mercury were exposed to nitrogen tetroxide vapours, the formation of mercurous nitrate is reduced to a minimum, and the greyish black substance is obtained in quantity. This substance on examination is found to be nitro-mercury : a complex containing mercury, mercurous oxide and some adsorbed nitrogen tetroxide.

219. Thermal decomposition of mercurous nitrite.

M. S. SHAH *and* B. G. JOSHI, Ahmedabad.

The decomposition of mercurous nitrite has been studied in detail by heating the substance in vacuo at various temperatures and analysing quantitatively the sublimate and the solid and gaseous products of decomposition at the end of each experiment. The decomposition which starts in the neighbourhood of 125°, becomes rapid when the temperature is raised, and comes to an end at about 300°.

The observations collected in the above experiments together with other facts noted in experiments on (i) the action of nitrogen tetroxide on mercurous nitrite at 100°, (ii) the interaction between mercury and nitrogen tetroxide at 200°, and (iii) the decomposition of mercurous nitrate above 100°, show that the probable mechanism involved is as follows :—

A part of mercurous nitrite decomposes initially into mercury and nitrogen tetroxide, as

$$HgNO_2 \rightarrow Hg + NO_2 \ldots\ldots (1).$$

In the second stage, nitrogen tetroxide produced in (1) reacts slowly with mercury as shown in the preceding abstract, and rapidly with undecomposed mercurous nitrite giving mercurous nitrate and nitric oxide according to

$$HgNO_2 + NO_2 \rightarrow [Hg(NO_2)_2] \rightarrow HgNO_3 + NO \ldots (2).$$

The mercurous nitrate so formed undergoes decomposition simultaneously under the conditions of the experiment, as

$$HgNO_3 \rightarrow HgO + NO_2 \ldots\ldots\ldots (3)$$

and the nitrogen tetroxide produced in (3) helps further conversion of mercury and mercurous nitrite into mercurous nitrate as shown above.

When all mercurous nitrite has thus undergone a change, the decomposition corresponds to that of mercurous nitrate.

220. The effect of addition of neutral salts on the total neutralizable acids of hydrogen clay sols.

RAMPRASAD MITRA *and* S. K. MUKHERJEE, Calcutta.

The effect of addition of neutral salts on the total neutralizable acids of hydrogen clay sols has been studied by potentiometrically titrating the pure sol, the sol-salt mixture *in situ* and the clear supernatant liquid above the coagulum of the sol-salt mixture. The bases used for the titration were NaOH, $Ba(OH)_2$, and $Ca(OH)_2$ and the salts added were NaCl, $BaCl_2$, and $CaCl_2$. The effect of addition of different concentrations of the salts has been studied. With a given base the total acid of the sol-salt mixture is considerably larger than that of the pure sol. Also, the form of the titration curve of the sol-salt mixture is materially different from that of the sol itself, the departure in form being most marked when NaOH is the base used for the titration. The total acid of the pure sol with $Ba(OH)_2$ is greater than that of the supernatant liquid of the sol-$BaCl_2$ mixture containing 0·1N $BaCl_2$. With NaOH, however, the total acid of the pure sol is considerably less than that of the supernatant liquid

of the sol-NaCl mixture containing 0·1N NaCl. The titration curves give evidence of surface reactions which involve a continued disappearance of the base and which are distinct from a simple neutralization of an acid by a base as ordinarily understood.

221. A discussion on the problems in lac industry.

H. K. Sen.

The secretion of the insect *Laccifera Lacca* Kerr, feeding on the sap of certain host trees, is responsible for the annual production of about one million maunds of lac, which constitutes an annual export trade to the tune of 2 to 3 crores of rupees, even at the present low price of shellac. As a natural resin, lac may be considered a perfect product in many senses, specially in its hitherto almost exclusive use in the varnish, electrical, and gramophone record industries. Since the advent of improved synthetic resins, this position is being threatened, and a crop which gave a substantial profit to the cultivator as a side show, is in danger of being discontinued on account of the low price it has been fetching for the last few years. The Government of India has recently increased the cess on exported lac by about 100% to enable intensive research being done to discover new uses for lac on the one hand, and modify its properties so as to make shellac more suitable for already existing uses on the other. To these may be added the improvement of the natural product itself as a whole. The modification of lac by physical and chemical methods is thus the most important problem from the technical point of view, and in this the true understanding of the constitution of shellac is absolutely necessary. Three research centres maintained and subsidized by the Indian Lac Cess Committee are busy investigating these problems—one at Namkum at the Indian Lac Research Institute, the two others in London and New York respectively.

Lac can be very broadly described as the aggregate of some hydroxy acids in a highly polymerized state in admixture with waxes and colouring matters which are of very minor importance. Whilst the former are regarded as esters, the latter are hydroxy methyl anthraquinone derivatives. The acids are only partly in the free condition, most of the acid portion being in a lactonic combination with OH- groups. Thus the average acid value of shellac is between 60 and 70, whereas the saponification value of shellac is as high as 220.

The shellac complex can be separated into two portions—one soluble in ether (about 30% of the total) and the other 70% insoluble in that solvent. The ether soluble portion called 'soft resin' contains about 4% wax, and freed from it, it has the following chemical constants:—

Acid value	98–100
Saponification value	201–203
Iodine value..	17–19
Molecular weight from saponification value, assuming monobasicity	276

The molecular weight thus corresponds to a monohydroxy palmitic acid.

The ether insoluble portion called the 'hard resin' or 'pure resin' has the following values: A.V. 55-56, S.V. 220–230, I.V. 11–14, M.W. from S.V. assuming monobasicity, 244. After saponification of the hard resin and separation of an acid, aleuritic acid, there remains about 70% which is again soluble in ether and has the characteristics which are not very dissimilar to those of soft resin. Up till now, two distinct solid acids have been isolated from saponified shellac—aleuritic acid (20–30% of shellac) and shellolic acid (about 10%). The rest are liquid hydroxy acids of varying acid values. Aleuritic acid has been definitely proved to be trihydroxy palmitic acid, $CH_2OH(CH_2)_5CHOH.CHOH(CH_2)_7COOH$, whilst the constitution of shellolic acid is not yet finally decided, Harries and Nagel considering it a condensed three benzene structure, in which the

orientation of the carboxyl and hydroxyl groups has yet to be determined. A special need for establishing the constitution of shellolic acid and the liquid acids lies in the fact that a large portion, about 70% of shellac is composed of these two, which are supposed to give the plastic property of shellac. All attempts to polymerize soft resin have as yet failed, but there are reasons to believe that this is mainly composed of hydroxy palmitic acids or their lower homologues. The part played by shellolic acid, its rather peculiar constitution, and its presence in the mixture of these liquid acids, which are palmitic in character have to be understood. Shellolic acid itself is difficult to isolate, and the identification of liquid acids, one of the most difficult problems of lac chemistry. Some light has been thrown recently by the work of the Indian Lac Research Institute on the nature of these liquid acids. A systematic examination of the acid values of various fractions has revealed that there is a group of acids which are essentially of lower molecular weights, and that the unsaturation as observed by the absorption of iodine or chlorine, is mainly confined to this portion of the acid. The latter, i.e. the iodine value has been tested in the Institute by three distinct methods, Wij's Chloramine method, and the iodochloride method of the Institute, and they all point to the definite existence of double bond of uniform value, indicating that the composition of the liquid acids is practically constant.

The hard resin has an iodine value 12–14, whilst that of the liquid acids, 17–19. As the liquid acids exist in the hard resin to the extent of 60%, the value 12–14 in hard resin is thus reconciled. It is established beyond doubt that the seat of unsaturation is in the soft resin, aleuritic acid being fully saturated.

The problem of modifying lac is being attacked from the following points :—

1. The condensation of the soft resin with reagents to yield hard resin. The reagents may be natural to lac itself or synthetics.
2. The condensation of the hard resin with reagents to yield improved shellac. These reagents may be natural to lac itself or synthetics.
3. The modification of shellac itself by the addition of special synthetics either mechanically or having them combined with the shellac complex in chemical or pseudo-chemical ways.
4. Improved thermo-hardening of shellac, and the resistance of moulded articles and film surfaces to water.
5. Polymerization and depolymerization of shellac for use in woven fabrics for specific properties.
6. Better adherence of shellac films on glass, wood, leather, and metal surfaces, as also its use as adhesives for laminated glass and mica sheets.
7. Use of shellac with fillers in 'injection moulding'.
8. Shellac-rubber combinations.

A technical method for the easy manufacture of aleuritic acid is considered to be of great importance, specially as the primary alcoholic group in aleuritic acid lends itself to easy oxidation to aldehyde, which can then serve as an active centre for further condensations. Various condensations with aleuritic acid, glycerol, phthalic, acid, etc. have been studied, some of which have given distinct promise of usefulness.

A probable scheme of lac formation from sugar and formaldehyde has been put forward, and the theories of resin formation have been critically examined.

SECTION OF GEOLOGY AND GEOGRAPHY

President :—W. D. West, M.A. (Cantab.), F.N.I.

Presidential Address

EARTHQUAKES IN INDIA

Contents.

Gentlemen,

In thanking you for the honour that you have done me in electing me to preside over your deliberations at this meeting, an honour I very greatly appreciate, I should like to say that I welcome the opportunity it has given me of placing before you a discussion of one of the most important of those problems affecting India in which the help of Science may be so fruitful. Earthquakes are one of the manifestations of Nature before which man unaided is almost powerless. He instinctively regards the earth on which he lives and has his being as sure and safe. But during an earthquake this illusion is suddenly destroyed, and the experience becomes one of the most terrifying ordeals a man may pass through. The help, however, that Science can provide may enable him, if not to prevent, certainly to diminish the worst effects of these evils. And with the bitter memory of the North Bihar and Quetta earthquakes fresh in our memory, I am justified, I think, in selecting 'Earthquakes in India' as the subject for my address to-day. I am also further encouraged by the fact that this subject has not before been chosen for discussion by any of my predecessors in this chair.

In approaching the subject of earthquakes in India, I do so as a geologist; and my main purpose is to show the close relation between the incidence of earthquakes and the geological structure of this country, and in this way to distinguish those areas of comparative safety from what I may term the danger zone of India. Though of late years this country has been rather backward in purely seismological research, the field investigations of all the more important Indian earthquakes have in most cases been conducted very thoroughly. This is work that requires the organisation of a department which can send out a party immediately after an earthquake, with full authority and adequate equipment. It is for this reason that these investigations have been done almost entirely by officers of the Geological Survey of India. The address that follows is based mainly on that work, and I am glad to acknowledge the debt that I owe to my colleagues of the Survey, both of the past and of the present.

I. THE BEGINNING OF THE SCIENTIFIC STUDY OF EARTHQUAKES IN INDIA.

The foundations of the scientific study of earthquakes in India were laid by Dr. Thomas Oldham, the first Director of the Geological Survey of India, when, with laborious and patient care, he compiled his 'Catalogue of Indian Earthquakes from the earliest time to the end of A.D. 1869'.[1] I have been unable to find out how it was that Oldham first became interested in the subject of earthquakes, but it seems likely that the impression he received of the immense damage done by the Burmese earthquake of 1839, when he visited Amarapoora in 1855, may have turned his attention to the subject. From his description of what he saw there, in which he writes 'I was unfortunately not then aware of the importance of such careful measurements of bearings and angles, as would now be sought for', it appears that he had not previously given much attention to the subject, and we may safely conclude that it was this visit of his to the Court of Burmah that was the starting point. The value of the work that he put into the compilation of his catalogue, for which he combed every possible source of information, both western and oriental, can hardly be overestimated, and we owe him a debt of gratitude. His other main contribution was the investigation of the Cachar earthquake of 1869. But, retiring from the direction of the Geological Survey of India in 1876, with his health broken, he was unable to complete the memoir on this earthquake; and it was left to his son, R. D. Oldham, to edit his notes and write the major portion of the volume.[2]

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[1] *Mem. Geol. Surv. Ind.*, XIX, Pt. 3, (1883).
[2] *Op. cit.*, XIX, Pt. 1, (1882).

The interest thus aroused in his son, R. D. Oldham, was to bear good fruit, for from that time the younger Oldham's thoughts can never have been far from the subject of earthquakes. His chance came when the whole of India was rocked by the great Assam earthquake of 1897. For though the field investigation of this earthquake was entrusted to five officers of the Survey including Oldham, it was Oldham who wrote the memoir on it, a memoir that has been described as being 'worthy of a great subject'.[1]

Though I have not the time now to appraise R. D. Oldham's influence on the science of seismology, I should at least refer to the great impetus given to this science by his discovery of the three main types of earthquake waves that are recorded on the seismograph, a discovery that has proved most fruitful in investigations regarding the internal structure of the earth.[2] On this occasion, so soon after his death, it is fitting that I should pay tribute to the memory of one who, more than any other, not only laid the foundations of earthquake research in India, but also deeply influenced the progress of the science as a whole.

II. THE ORIGIN OF EARTHQUAKES.

The subject of the origin of earthquakes is sufficiently large to occupy the whole of a presidential address. I do not intend to discuss the problem here, but a few words are necessary as an introduction to what follows.

It seems appropriate that I should first refer to the origin of earthquakes envisaged in Hindu mythology. It is generally believed that Vasuki, the multi-headed king of serpents, carries the earth on one or other of his many hoods. In time the weight of the earth proves tiring to the serpent, and to get relief the earth is transferred from one hood to another, and in consequence the earth quakes! Other explanations have also been put forward, some authorities thinking that earthquakes are caused by water monsters, while others think that the elephants presiding over the quarters are responsible. However much we may be intrigued by the picturesque origins thus assigned to our subject, time necessitates that I should leave the matter there, and get back to the more prosaic facts of observation.

Confining our attention solely to tectonic earthquakes, a class that includes the majority of shocks, examination of the distribution of earthquakes of this type throughout the world shows that they are very closely connected with mountain ranges of recent formation. This relation is well brought out in India, where almost all severe earthquakes are located along the flanks of the Himalaya and its associated ranges, while none occur in association with the older Aravalli, Vindhya or Satpura

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[1] *Op. cit.*, XXIX, (1900).
[2] *Phil. Trans.*, 194-A, p. 135, (1899j.

ranges of Peninsular India. And the fact that the formation of mountain ranges is inevitably accompanied by the fracturing of the rocks along faults and overthrusts, and that earthquakes can sometimes be definitely correlated with movements along faults, explains the association of earthquakes with recently formed mountain ranges, or with those that are in process of formation. And though it is a jump in the argument to say that most earthquakes, therefore, originate in movement along faults, the balance of evidence is that this is the correct interpretation, though the nature of the faulting may be variable, and not necessarily connected with folding. In this view the stresses that have been slowly accumulating in the rocks are relieved by fracture, and the elastic waves thus generated provide the phenomena that we associate with an earthquake.

In the history of Indian earthquakes we know of three cases in which actual fracture of the rocks along a fault accompanied the shock; the Cutch earthquake of 1819, the Chaman (Baluchistan) earthquake of 1892, and the Assam earthquake of 1897. In other earthquakes no visible faulting at the surface of the ground seems to have occurred, and if these earthquakes originated in movement along faults, then either those faults did not reach the surface, or the movement along them occurred only in depth, and died out before reaching the surface.

Though movement along a fault seems sufficient to account for the observed phenomena, an alternative explanation has been put forward by R. D. Oldham.[1] Observing unaccountable variations in the intensity of both the Assam and Cutch earthquakes in the area over which they were felt (both of them earthquakes in which faulting took place), he suggested that the real cause was more deep-seated, and due to a sudden change in the nature of the rock in depth, such as would occur if eclogite changes to basalt, these two rocks having the same chemical composition but different densities. Oldham looked upon these changes as the origin of the shock, regarding the faulting as a surface phenomenon of secondary importance. And though such an explanation may possibly account for some very severe earthquakes of considerable depth of focus, in most cases movement along the fracture seems sufficient to account for the observed phenomena. Oldham's consideration of the problem really concerns the origin of the stresses that lead up to the fracture, which is a more fundamental problem, and beyond the compass of this address.

Before concluding this section, I would draw your attention to Col. E. A. Glennie's conception of crustal warping and its relation to the origin of earthquakes.[2] This idea has received

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[1] *Op. cit.*, XLVI, Pt. 2, (1926).

[2] 'Gravity anomalies and the structure of the earth's crust,' *Survey of India, Prof. Paper* No. 27, (1932); and Geodetic Report for 1936, not yet published.

a good deal of attention lately from those endeavouring to determine which areas within the earthquake belt can be regarded as most susceptible to shocks. According to Col. Glennie, areas of negative anomaly, in other words his 'downwarps', are areas in which earthquakes are most likely to occur. There is still, however, a long way to go before the observed facts of geology and the geodetic evidence can be satisfactorily correlated. And though the full acceptance of his views on the distribution of earthquake incidence may be unwise in these early stages of the theory, it is, nevertheless, a conception that should be considered by everyone interested in the problem of the origin of earthquakes.

III. THE STRUCTURE OF INDIA.

As Sir Thomas Holland has pointed out, within the boundaries of the Indian Empire we have, paradoxically, examples supporting both the doctrine of the permanence of continents

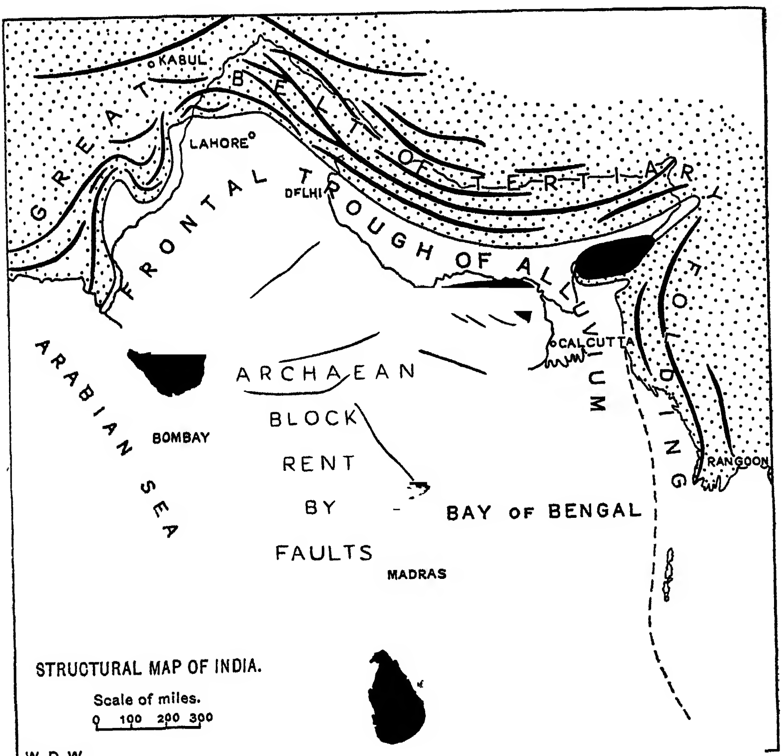

FIG. 1.

and oceans, and the conception of the complete mobility of the earth's crust. The main elements of the structure of India are shown in a simple way in figure 1. On the north-west, north and north-east is the mobile belt of Tertiary folding, comprising the Himalayas and its associated ranges. To the south of this comes the frontal trough or ' foredeep ', filled with the alluvium of the Indus and Ganges plains. The third element comprises the peninsular of India, composed of a stable block, unfolded since very early times, but greatly fractured by faults. Though there is thus a clear distinction between the three elements on structural grounds, the stability of the peninsular block should not be over-emphasized, nor the peninsular character of a portion of the Himalayas lost sight of.

Though relatively stable, the peninsular block is rent through and through with faults. Some of the more important of these are shown in white in figure 1. They vary greatly in age. The boundary fault of the Vindhyan basin is probably post-Vindhyan and pre-Talchir; the faults bounding the Gondwana basins are thought to be Jurassic in age; the Ellichpur fault in the Central Provinces, and other similar faults cutting the Deccan trap, are post-Cretaceous; while the faulting that produced the western coast of India must be of very recent age. Some of these faults are of great throw, the boundary fault of the Ranigunge coalfield by Panchet hill having, according to Mr. E. R. Gee, a throw of over 9,000 feet.[1]

Regarding the Tertiary folded belt, the late Sir Henry Hayden long ago pointed out the peninsular character of the rocks forming the southern slopes of the Himalayas.[2] More recently Mr. J. B. Auden has further emphasized the resemblance on the evidence of the palæo-climates.[3] We have, therefore, to envisage during the Tertiary ' revolution ' not only the folding of the main geosyncline of the Tethys, but also the folding and fracturing of the northern edge of Gondwanaland, which thereby got incorporated in the rising mountain range. At the same time the buckling down of the Gangetic trough took place, and, from a geographical point of view, caused the separation of Peninsular from extra-Peninsular India.

Regarding the general shape of the belt of folding, the disposition of these mountain arcs about the continent of India, itself composed of old and rather unyielding rocks, suggests that the shape of the belt as a whole has been determined to some extent by the shape of the mass against which it impinged, though the fact that the edges of the continental mass have also become involved in the folding shows that the problem is not a simple one. Mr. D. N. Wadia, in his paper on the syntaxis

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1 *Mem. Geol. Surv. India*, LXI, p. 101, (1932).
2 *Rec. Geol. Surv. Ind.*, XLIII, p. 141, (1913).
3 *Op. cit.*, LXIX, pp. 154–161, (1935).

of the North-Western Himalaya, after showing that there is a complete unity of structure and stratigraphy round this great bend in the alignment of the mountains, suggested that a ridge of continental India extends up to the north-west beneath the younger rocks, and that it has acted as an obstacle around which the mountain waves have been deflected.[1] More recently he has discussed the very similar, though more abrupt, re-entrant in north-east India.[2] And although the facts available from this area are rather scanty, he suggests that there is probably a similar continuity of trend line around this bend, and that a similar explanation may apply. In which case the isolated fragment of Peninsular India forming the Assam range must have provided the obstacle that deflected the trend lines. It may be that a similar explanation also applies to the re-entrant angle in the Baluchistan mountains between Sibi and Quetta, where the trend lines of the mountains are so sharply deflected. This point, however, is discussed in greater detail below.

Such in very brief outline is the structural framework of this country. A more detailed analysis of a part of it will be given in a later section, but this introductory explanation is necessary for a complete view of the picture.

IV. THE DISTRIBUTION OF EARTHQUAKES IN INDIA.

In the previous section I indicated in brief outline the general structure of India, showing that there were three main elements. Considering now the distribution of earthquakes in India, we find that they are confined almost entirely to the southern border of the belt of Tertiary folding, and that the Archaean block of Peninsular India has been almost free from all but the most minor shocks. This zone of earthquake activity, passing through northern India and Burma, is but a part of the great east to west earthquake belt that extends from the Alps to the East Indies. This belt occurs in close association with the great belt of Tertiary folding, a convulsion that has not yet entirely died out, especially at its eastern end, and the connection between these two in a general way is quite evident.

To show clearly the disposition of the earthquake belt in India, I have prepared the map forming Plate 3. In delineating the southern edge of this belt, two courses were open. The boundary could be drawn so as just to include to the north of it all the known epicentres of important earthquakes. This, however, might have given a false appearance of security to those places just south of the boundary, some of which, though at some distance from the nearest epicentre, have been severely damaged in the past. The second course was to enlarge the zone

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[1] *Op. cit.*, LXV, pp. 189–220, (1931).
[2] *Him. Journ.*, VIII, p. 63, (1936).

so as to include within it all places liable to severe damage from earthquakes. This, however, would have failed to bring out clearly the zone of epicentres in which movement resulting in earthquakes is actually taking place. In the end I have adopted neither course, but instead have drawn two zones, one that includes the epicentres of all severe earthquakes since 1850, and another parallel to it that includes places that might be severely damaged by earthquakes originating in the zone of epicentres. These two zones are coloured red and yellow on the map, and in the former the epicentres are shown in a darker shade of red. The southern boundary of the yellow zone is based mainly on the limits of the areas known to have been damaged by the earthquakes whose epicentres are shown,[1] and partly on general grounds. It is unfortunate that these zones coincide with the most densely populated tract in India.

To the south of these two zones there comes the area coloured green, indicating comparative safety. It roughly corresponds to the boundaries of the stable block of Peninsular India. Although severe earthquakes are practically unknown in this area,[2] minor shocks are frequently felt, especially in South India. As already indicated, although Peninsular India resisted the folding of Tertiary times, except along its northern border, it is greatly fractured by faulting, which suggest that it is not so stable as is generally supposed. These minor shocks may therefore be attributed to the strained condition that characterizes the Peninsular. In this connection I would suggest that those sympathetic shocks that are sometimes felt in Peninsular India at very nearly the same instant as a severe earthquake occurs in Northern India, as for example at the time of the Srimangal and North Bihar earthquakes, are further evidence of the strained condition of the Peninsular, the vibrations of the crust emanating from a focus in Northern India being sufficient to precipitate minor shocks in the Peninsular.

Regarding the epicentres shown within the red zone, a word of explanation is necessary. In most cases the shape and size of the epicentres given on the map is a copy of that constructed by the authority who investigated the earthquake. In one or two cases, however, modifications have been introduced. In the first place, in order that the size of the epicentres might roughly indicate the intensity of the shock, isoseist 9 (Rossi-Forel scale) has been taken as the boundary in each case. Thus the epicentral area of the North Bihar earthquake is shown considerably bigger than it is on the map accompanying the

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[1] Based on a map constructed by Mr. J. B. Auden for departmental use.

[2] The only severe earthquake known to have affected Peninsular India occurred over the Deccan in 1843. It did a certain amount of damage, and appears to have been centred near Bellary.

geological report, though the boundary used by me is of course the same as isoseist 9 given in that report. Where there has been superficial evidence of two foci, as in the Kangra and North Bihar earthquakes, I have omitted the minor focus. In neither case did the instrumental evidence allow the possibility of two foci, and the phenomena were possibly due to some superficial effect. In the case of the Cutch earthquake of 1819, insufficient data rendered the drawing of isoseists impossible. But R. D. Oldham considered that the area of severe damage was about two-thirds the size of the area of severe damage in the Assam earthquake of 1897, and I have drawn the epicentre of the Cutch earthquake of an appropriate size around the surface fault that developed at the time of the earthquake.

In the map that has been constructed it has only been possible to insert the epicentres of severe earthquakes that have occurred since 1850 (including the Cutch earthquake of 1819). This is due to the fact that previous to that no earthquake had been investigated scientifically; and though we know in many cases the approximate position of the epicentres of the older earthquakes, in most cases the only information available gives the names of towns in which the shock was felt, and this must depend on the accidental fact of its having been recorded in writing at those particular places. To take an example, the severe earthquake of 1803 did much damage at Muttra (near Agra), but it was also severe in the Simla and Kumaon hills. This information is clearly insufficient to determine the location of the epicentre. It is for this reason that there are gaps in the red zone of the map in which no epicentres are shown, and this may give a false impression. To get over this difficulty I have added at the end of this address a list of important Indian earthquakes. This is mainly based on T. Oldham's catalogue, and extended up to the present day. To a large extent it closes up the gaps shown on the map.

V. THE STRUCTURE OF THE EARTHQUAKE BELT.

The occurrence of earthquakes in India is a legacy of the great earth movements that convulsed the northern flanks of India during Tertiary and Quaternary times, leaving behind an unstable belt in any part of which earthquakes are liable to occur. The origin of earthquakes within this belt must, therefore, in a general way, be everywhere the same. Nevertheless, the detailed structure of the belt varies considerably from place to place, and consequently the exact mode of origin of the earthquakes that occur within it also varies. I propose, therefore, to discuss the structure of this belt in five sections, selecting five areas of special interest.

1. Cutch.

Had the great Cutch earthquake of 1819 never occurred, it is doubtful if the marked instability of this area would have been recognised. In the next section on Baluchistan it is pointed out that southwards from Quetta the incidence of earthquakes gradually decreases, while their intensity also diminishes, so that in Makran earthquakes are comparatively rare, and such as occur are of slight intensity. The reason that I have previously advanced to account for this is that away from the re-entrant angle in the alignment of the Baluchistan hills by Quetta and Sibi, the folding of the rocks becomes progressively less intense, and consequently the earthquakes attributed to that folding become less common and less severe.[1] But in the vicinity of the Arabian Sea, although the influence of the folding has become almost negligible, a new factor is introduced that increases the danger once more.

W. T. Blanford, in his introduction to the first edition of the Manual of the Geology of India, suggested that the Baluchistan and Sind coastline is a fault scarp, and that land which once extended out into the Arabian Sea has been faulted down beneath the waves.[2] This view has recently received support from the work of the John Murray Expedition under the leadership of Lieut-Col. R. B. Seymour Sewell. The data obtained by this expedition, and summarized by Wiseman and Sewell in a paper contributed to one of our discussions at this Congress, show that there is a submerged line of interrupted ridges some 60 miles off and parallel to the present coastline; while a second double ridge begins at Cape Monze, near Karachi, and continues south-west across the entrance to the Gulf of Oman. They are of opinion that the latter is a direct continuation of the Kirthar range, as indeed seems very likely. And since the Kirthar range is composed of Gaj and Nari beds, the faulting that fractured this range, and caused its subsidence beneath the sea, must be at least post-Lower Miocene in age; and, since the faulting was posterior to the folding, probably very much younger. They conclude that the present submarine topography of this part of the Arabian Sea developed as a result of compression during late Tertiary times, after the manner of the 'ramp' valleys of the Great Rift Valley of Africa.

In view of the above facts, the occurrence of a great earthquake in Cutch need no longer be regarded as inexplicable. The earthquake in question became famous in geological literature largely through the description given by Sir Charles Lyell in his 'Principles of Geology'. More recently the late

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[1] *Rec. Geol. Surv. Ind.*, LXIX, p. 218, (1935).
[2] A Manual of the Geology of India, p. lxxi, (1879).

Mr. R. D. Oldham collated all the available information, and gave a critical discussion of the events of the earthquake.[1] The main happening was the formation of a big dislocation running somewhat sinuously through the northern part of the Runn of Cutch for a distance of nearly 90 miles. It was marked by a general uplift of the country to the north and of subsidence to the south, the maximum differential movement being about 30 feet. It was this subsidence to the south that caused the flooding of the Runn of Cutch, and the submergence of the town of Sindree and other places. Now the general east and west alignment of this dislocation is more or less on the same line as the inferred faulting that must have caused the subsidence of the southern coast of Baluchistan and Sind beneath the Arabian sea. It seems likely, therefore, that the earthquake of 1819 was part of the same train of events, indicating that instability still persists. It is perhaps worth noting that had Karachi been in existence as a large city at the time of this earthquake, it must have been seriously damaged.

The only other information that we have of earlier earthquakes in this area concerns an earthquake in 1668, a short account of which is given in Oldham's catalogue. The report states that the town of Samaji, on the delta of the Indus, sank into the ground with 30,000 houses during an earthquake. This number must of course be an exaggeration, but the shock was evidently a severe one.

2. Baluchistan.

Baluchistan is an area of exceptional interest, and demonstrates well the close connection between the location of earthquakes and the geological structure.

The mountains of Baluchistan are a southward branch of the great Tertiary mountain system, of which the Himalayas form a part. They differ, however, from that great range in containing none of the old metamorphosed crystalline rocks which are such a feature of the central axis of the Himalaya. In Baluchistan the oldest rocks are of Carboniferous age, though the greater portion are younger and include the great Siwalik series of rocks of Miocene to Pliocene age.

Consideration of the distribution of the mountains of Baluchistan, given on Plate 2, shows that their general north and south alignment is interrupted by a sharp re-entrant angle in the region of Quetta and Sibi. From Quetta southwards, along the Kirthar range to Karachi, the mountains run north and south ; while the same is true of the Sulaiman range southwards from Dera Ismail Khan. But from Dera Bugti to Quetta there is a sharp bend up to the north-west, the Bolan

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[1] *Mem. Geol. Surv. Ind.*, XLVI, Pt. 2, (1926).

pass, situated between Sibi and Quetta, marking the north-west end of this big re-entrant. This alignment of the mountains of Baluchistan is but a reflection of the geological structure to which they owe their origin, for there is a very intimate connection between the geography and geology, anticlines having given rise to ridges and synclines to valleys. And since the geology and geography are so closely related, the map given on Plate 2 gives also a good idea of the general geological structure of the country, the axes of the rock folds being everywhere parallel to the trend lines of the mountains. Thus between Quetta and Karachi the folding movement which has produced the Kirthar and other ranges has acted in a west to east direction. To the east of Quetta, in the Zhob-Harnai system of mountains, the movement has been towards the south and south-west. In the Bugti hills the folds are displayed in a big curve facing south, due to movement from north to south. While in the Sulaiman range the movement has once more been from west to east. It is as though in the general sweep eastwards the folds had been held up by some obstacle in the Quetta-Sibi area, which has disturbed the general north and south alignment of the resulting hills.

We owe much of our knowledge of the geology of this area to the researches of the late Mr. E. W. Vredenburg,[1] earlier workers including W. T. Blanford, C. L. Griesbach, and R. D. Oldham. Vredenburg showed that the area consists of three main tectonic elements. The central element is the folded mountain tract, characterised by a great abundance of limestones, but fringed on its western side by a zone of soft shales of Oligocene age, of the nature of 'flysch'. The western boundary of this mountain area is marked by a long boundary fault, which separates the mountains from the flat desert plain of Registan on the west. The line of this fault has been the site of many earthquakes in the past, and Vredenburg has shown that the country west of the fault has subsided several thousand feet, this area being regarded by him as a subsided 'hinterland'. The third element is the flat alluvial covered edge of the Indian peninsular, bounding the mountain tract on its east. On this side there is no sharp boundary fault, but instead the hills rise up gently from beneath the alluvium. It includes the alluvial tract of the Indus valley, and is of the nature of a 'foreland'. These three tectonic elements are shown on the map forming Plate 2.

Regarding the details of the structure, Vredenburg showed that while throughout the greater part of the central mountain tract the folding of the rocks is comparatively simple and free from faults, in the neighbourhood of Quetta the structure

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[1] *Rec. Geol. Surv. Ind.*, XXXVIII, p. 189, (1909).

becomes much more complicated; the folds become more tightly packed, and several thrust faults have developed whereby the rocks on the north-west side have been thrust over those on the south-east side. It is significant that this is the only part of Baluchistan and Sind where thrust faults are known to occur.

It has been suggested that the re-entrant angle in the alignment of the hills has been caused by an underground tongue of Peninsular India obstructing the free movement of the folds towards the south-east. The effect may be likened to the waves of the sea when they are deflected in their course towards the shore by the obstruction of a breakwater. The waves flow freely by on either side, but are held up by the breakwater. Whether or not this hypothesis is correct, it is a fact that the geology around this re-entrant angle is more complicated than it is in any other part of Baluchistan, and that the rocks have yielded here not only by folding but also by fracture. It is, therefore, in this very area, where a condition of great strain must exist, that one would expect most earthquakes to originate.

When now we come to examine the distribution of earthquakes in Baluchistan and Sind, the facts are very significant. On Plate 2 is shown the distribution of earthquakes that are known to have occurred in this area since 1852, and which have been strong enough to cause damage to buildings. The manner in which they are grouped around the re-entrant angle is very striking, and cannot be accidental. Earthquakes have also occurred elsewhere, but their intensity has been slight; and what may be termed the danger zone of this part of the earthquake belt of India appears to lie within a radius of about 150 miles of Mach.

Plate 2 also brings out another interesting fact. The order in which the earthquakes have occurred is indicated in numbers, and it will be seen that the earthquake focus has shifted from place to place in an apparently haphazard fashion, and has not occurred twice running in the same place. The reason for this seems clear. It is generally accepted that earthquakes of this nature afford relief to the stresses that have accumulated in the rocks. Therefore, when an earthquake occurs in any particular place, the fact that it has relieved the stresses at that place suggests that the next earthquake is unlikely to occur again in exactly the same place, but rather in some adjacent area where the stresses have not been relieved. This principle was first suggested by the late Dr. Omori in 1907, and its implication regarding, for example, the new site for Quetta is obvious. To the uninitiated the decision to rebuild Quetta in exactly the same place seemed to be almost foolhardy; but in view of the above facts regarding the distribution and sequence of earthquakes in this area, it is clearly the only safe policy.

Thus in broad outline the incidence of earthquakes in Baluchistan and their general distribution are understandable, and in keeping with what we know of the geology of this section of the earthquake belt. When, however, we consider the actual origin of these earthquakes, we have to admit complete ignorance in most cases. With the exception of the Chaman earthquake, none have been connected with movement along any visible fault; though, wherever information is available, it is found that the axis of the epicentre has coincided with the strike of the rocks. In the case of earthquakes originating near Chaman, there has always been observed a movement along the great fault that bounds the mountain area on the west. This movement was carefully studied at the time of the 1892 earthquake by C. L. Griesbach, who, by examining the distortion of the railway line where it crossed the fault, showed that the country to the west of the fault had subsided from eight inches to a foot, and had moved about two and a half feet bodily southwards with respect to the country east of the fault.[1] Later, Sir C. A. McMahon, when demarcating the Baluch-Afghan boundary in 1896, followed the fissure marking the trace of the fault for 120 miles.[2] Subsequently, E. W. Vredenburg, as a result of mapping the geology of this area, concluded that the country to the west of the fault had subsided altogether several thousand feet.[3] Apart from this well-known example, however, it is not possible to correlate any of the other Baluchistan earthquakes with movement along faults; and, if they have been connected with faults, then those faults must be ones that do not reach the surface of the ground. Whatever their exact origin has been, however, in view of the facts given above regarding their distribution and sequence, it seems likely that they have been connected with the stresses that must exist at the head of this acute angle in the alignment of the mountains.

Whether the movement that is going on at the present day and manifesting itself in earthquakes represents an attempt by Nature to straighten out this irregularity in the alignment of the mountains; or whether it is due to further development of the re-entrant by movement on either side of it; or whether all positive action has now ceased, and such movement as is indicated by the earthquakes represents merely the relief of stresses that have developed in the past, it is not possible to say. But the fact that earthquakes are comparatively frequent in this part of India shows that the stresses in the rocks, to whatever cause they may be due, are being relieved more or less continuously, and are not being allowed to accumulate

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1 *Rec. Geol. Surv. Ind.*, XXVI, p. 57, (1893).
2 *Geogr. Journ.*, IX, p. 402, (1897).
3 Baluchistan District Gazetteer. V. p. 18, (1907).

to the extent of providing a shock of the greatest destructive intensity, comparable to the great earthquakes of northern India.[1]

3. Northern India.

In the structural map of India given in figure 1, the ' Frontal Trough of Alluvium ' is shown as a single unit. Although from the genetic point of view this is probably correct, it is doubtful if the trough is uniform in structure. It is in fact probably only correct to describe it as a deep trough in that part of it which extends from about Moradabad to Purnea. In the north-west part of the belt the presence of outcrops of Archaean rocks in the Punjab, forming the Kirana hills, and the results of geophysical work, suggest that the alluvium is here merely a thin covering to the older rocks, indicating an extension of the Indian peninsular to the north-west at a shallow depth. Regarding this deep trough, its north-western boundary is the continuation of the line of the Aravalli hills beneath the alluvium north-eastwards from Delhi, a feature anticipated by geological considerations and confirmed by geodetic observations. Its south-eastern boundary is more difficult to define, but it is doubtful, according to Oldham, if the alluvium east of the Rajmahal hills, stretching southwards to the Ganges delta and eastwards up the valley of the Brahmaputra, is more than a comparatively thin covering. Within these limits there occurs a deep trough, concerning the origin of which almost as much literature has appeared, both from geologists and geographers, as would suffice to fill it up.

W. T. Blanford, in discussing the origin of the Indo-Gangetic plain, sought rather to disprove the contention that it was an ancient sea filled up by deposits brought in by rivers, than to discuss its origin.[2] Much later, in 1890, C. S. Middlemiss recognized this belt as a zone of subsidence ; and, as a result of his work in the sub-Himalayan tract of Garhwal and Kumaon, he showed that the sinking of the plains and the rising of the mountains were complementary phenomena that had gone on at one and the same time.[3] It was not, however, until 1909 that E. Suess, in his great work ' Das Antlitz der Erde ', using more modern nomenclature, referred to this zone as being the ' foredeep ' of the Himalaya. The dominant note of Suess's great work as regards mountain building was that mountain ranges were not produced by an equable movement of two crustal masses against each other, but rather that a unilateral movement occurred, giving rise to the contrast between the

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[1] For a general account of Baluchistan earthquakes see W. D. West : *Mem. Geol. Surv. Ind.*, LXVII, (1934) ; and for an account of the Quetta earthquake see W. D. West : *Rec. Geol. Surv. Ind.*, LXIX, p. 203, (1935).

[2] A Manual of the Geology of India, p. lx. (1879).

[3] *Mem. Geol. Surv. Ind.*, XXIV, Pt. 2, p. 141, (1890).

foreland and the backland, and leading to the idea that the foreland is overtaken by the folding, and is in fact forced down by the advancing range. With this grand conception of the origin of the major features of the earth's surface carrying a large measure of acceptance amongst geologists, there then came Sir S. G. Burrard's startling views, given in a short paper in 1912,[1] and amplified on the occasion of his presiding over the third Indian Science Congress at Lucknow in 1916.[2] Burrard's hypothesis, based on geodetic evidence, was that a great sub-crustal crack or rift, perhaps as much as 20 miles in depth, had developed through a length of over 2,000 miles and become filled in with alluvium. He regarded the Gangetic trough as a zone of tension, alongside the Himalayas which he agreed was a zone of compression. He went even further, however, and looked upon the rifting as the primary event, with the consequent compression of the Himalayas to the north as a secondary event, consequent upon the rifting.

This conception, startling to the geological mind, drew down upon its author's head the wrath of R. D. Oldham. The latter, in a lengthy memoir, discussed in detail the geodetic evidence, especially with regard to the light it threw on the shape of the floor of the Gangetic trough.[3] He concluded that the maximum depth of the trough near its northern limit was between 15,000 and 20,000 feet; and that from this maximum depth, at a distance of from 10 to 30 miles from the northern edge of the plain, the floor slopes upward fairly uniformly to the southern edge, where it emerges as the northern edge of the peninsular. Thus in his view the floor of the trough was not a rift or crack, but a more or less uniform slope dipping northwards, and rising rapidly at its northern edge towards the Himalayas. This view of the structure had, of course, been held for some time by geologists,[4] but the confirmation that Oldham provided, based on both geodetic and geological considerations, was reassuring.

Whether the maximum depth is as much as 15,000 to 20,000 feet is possibly open to doubt. This figure is, however, in no way absurd, since the thickness of the Siwalik deposits on the northern side of the trough, which were formed under precisely the same conditions as the Indo-Gangetic alluvium, but at a slightly earlier date, is more than 15,000 feet. Nevertheless recent calculations by Col. E. A. Glennie suggest a depth of about 6,500 feet or even less, and the actual maximum depth must still be held to be a matter of some uncertainty.[5]

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[1] 'On the Origin of the Himalaya Mountains', *Survey of India, Prof. Paper* No. 12, (1912.)

[2] *Proc. Asiat. Soc. Bengal,* N.S., XII, No. 2, p. lxxx, (1916).

[3] *Mem. Geol. Surv. Ind.*, XLII, Pt. 2, (1917).

[4] *Rec. Geol. Surv. Ind.*, XLIII, Pt. 2, (1915).

[5] *Survey of India, Prof. Paper,* No. 27, p. 19, (1932).

Considering now the structure of the great mountain belt on the north side of the trough, H. B. Medlicott, and later R. D. Oldham, laid great stress on the 'main boundary fault', a feature that was not only a fault but also a limit of deposition. So great was the emphasis laid on this fault, that it gradually came to be regarded as the dominant feature of Himalayan tectonics, and even as a basal thrust plane along which the Himalayan arc had formed and moved.[1] But so long ago as 1890 C. S. Middlemiss showed that, in addition to Oldham's 'main boundary fault', there were similar thrust faults of equal importance within both the Tertiary and pre-Tertiary rocks, and more recent work on these latter rocks by Dr. G. E. Pilgrim, Mr. D. N. Wadia, Mr. J. B. Auden and the speaker has only served to emphasize the importance of these other thrusts.

The exact age of these various Himalayan thrusts is not always easy to determine, but, as Mr. Auden has pointed out, they must have taken place over a considerable length of time, some being pre-Pliocene and some post-Pliocene.[2] There is no doubt, however, that the movement has continued up to very recent times. Sir Edwin Pascoe has observed tilted and almost vertical Pleistocene conglomerate, in one place folded into a syncline, at Golra, near Rawalpindi [3]; while Mr. D. N. Wadia has recorded vertically folded Lower to Middle Pleistocene conglomerate extending for many miles along the north rim of the Soan syncline, the age of which has been determined from their fossil mammals.[4] More recently Mr. H. M. Lahiri has found, at the edge of the foot-hills to the west of Simla, Dagshai (Miocene) beds resting nearly horizontally on the top of the Older Alluvium (Pleistocene), indicating that the thrusting has continued to a very late date.[5] Thus from the Siwalik hills overlooking the alluvium of the plains, to the inner ranges of the Himalayas proper, there occur numerous thrust faults one behind the other, some of which, in the forefront, are of very recent age.

It was long ago shown that the deposits of which the Siwalik rocks are formed closely resemble the recent deposits of the plains, so much so that the Siwalik hills have been looked upon as an elevated portion of the plains, a recent accretion, as it were, to the advancing mountain range.[6] The next line

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1 For a fuller discussion and references, see *Current Science*, III, p. 235, (1935).

2 *Rec. Geol. Surv. Ind.*, LXVII, p. 445, (1934).

3 *Mem. Geol. Surv. Ind.*, XL, pp. 395, 397, and 451, (1920).

4 *Op. cit.*, LI, Pl. 9, (1928).

5 *Rec. Geol. Surv. Ind.*, LXIX, p. 73, (1935).

6 Whether Central Asia has advanced and overridden India, or whether India has moved north and underthrust Asia is immaterial in this place, though the latter is more likely. A fuller discussion of this question is given in *Current Science*, III, p. 235, (1935).

of hills to the north of the Siwalik hills comprise estuarine and lacrustrine deposits of an age older than the Siwalik rocks, but which also must have been formed in the main of detritus derived from an already partly raised mountain range. We are thus presented with the picture of a slowly advancing range gradually attaching to itself deposits that have been derived from its own denudation. There is no reason to suppose that such movement has yet come to an end, and it seems logical to infer that in time the alluvial deposits immediately in front of the Siwalik hills will themselves be folded, thrust-faulted and upraised to form yet another range of hills in advance of the Siwalik hills, and yet another accretion to the southern face of the great mountain range. The point that I wish to emphasize is that though the exact age of the various thrusts, and their relative order of maximum activity, cannot always be determined, in general there has been a southward migration of activity, so that at the present day, when the older and more northerly thrusts have long since ceased to move, and have indeed been deeply dissected, the locus of activity is along the southern margin of the hills or even further south out into the plains.

The picture drawn above bears some similarity to Grabau's theory of migrating geosynclines. Grabau, indeed, actually applied his theory to the area that we are discussing. In his way of putting it, when the strata of the Himalayan geosyncline became folded and upraised, the geosyncline shifted southwards and became the Siwalik geosyncline, though for the most part the subsidence of the latter never carried its surface below sea-level. Later, the deposits of this geosyncline in their turn became folded into the Siwalik hills, and the geosyncline shifted once more southwards, becoming what we know as the Gangetic trough.[1]

Regarding the origin of the Gangetic trough, a good deal of loose thinking has always seemed to have characterized the discussion. Too much emphasis has been laid by various writers on the part played by the denudation of the mountains and concomitant deposition in the trough, as though this deposition of sediment was the cause or part cause of the sinking of the trough. A moment's consideration will show that such cannot have been the case. If the deposition of sediment be regarded as the cause of a depression, then such deposition can only depress the surface of the crust to the extent that it is able to displace material below; and since the latter has a much higher density than the unconsolidated sediment, the trough must soon become filled up and the process end, for deposition cannot take place on dry land, except to a negligible extent. Hence the gradual

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[1] Grabau, A. H., 'Stratigraphy of China', II, p. 256, (1928).

sinking of the trough and the deposition of thousands of feet of sediment in it must have had an altogether different origin. Moreover, the trough probably started as a downwarp of the crust as early as Eocene times, that is before the main uplift of the Himalayas had begun, and therefore before a big range was available for rapid denudation. It is much more logical to suppose that the compression that produced the folding and thrusting in the Himalayas was also responsible for the down-warping of the trough. The problem to be solved is much the same as the problem of the origin of geosynclines. In the history of a geosyncline there has occurred long continued sinking keeping pace roughly with the deposition of comparatively shallow water deposits. But, for the reasons given above, the cause of the continued sinking cannot be the deposition of the sediment, and the general problem of the formation of geosynclines still remains obscure.

We are now in a position to discuss briefly the origin of the two most severe earthquakes that have affected northern India during the present century, namely the Kangra earthquake of 1905, and the North Bihar earthquake of 1934, both of them shocks of the greatest intensity.

The Kangra earthquake was the subject of two reports by Mr. C. S. Middlemiss, in both of which he has discussed the geological conditions relating to the earthquake and its origin.[1] For reasons already given, on the earthquake map forming Plate 3 I have only indicated the main epicentre. From the way in which the epicentre of this earthquake coincided with the 'main boundary fault' separating the younger Tertiary from the older Tertiary rocks, it has commonly been assumed that the earthquake was due to movement along the boundary fault. Middlemiss, however, never made any such statement, but, in his usual cautious way, only concluded that the earthquake was due to 'a sudden rupture or release of strain occurring among or below the folded sub-Himalayan formations at two places where the strain was specially great owing to resistances to the well established forward march of the overthrusting foot of the Himalayan range and where packing, with consequent arching, may have brought about a certain loss of isostacy'. In no place was he able to detect any movement of the ground along the line of the main boundary fault. The assumption that there was a connection between the main boundary fault and the earthquake may also have arisen from the fact that Middlemiss drew attention to the manner in which the epicentre coincided with an embayment northwards of the line of the boundary fault, and suggested that the earthquake was to be attributed to an attempt to straighten out this irregularity.

[1] *Rec. Geol. Surv. Ind.*, XXXII, p. 258, (1905); and *Mem. Geol. Surv. Ind.*, XXXVIII, (1910).

However that may be, there is one aspect of the matter which proves conclusively that the earthquake cannot have been due to movement along either of the two boundary faults.[1] Middlemiss estimated that the depth of the focus of the earthquake was between 21 and 40 miles. And, although the method of estimating used by him thirty years ago would to-day be considered rather inadequate, there can be little doubt that an earthquake felt over such an extremely large area (1,600,000 square miles), and accompanied by only moderate violence at the surface, must have had a fairly deep focus, as Middlemiss pointed out. It is thus clear that the focus can have had no connection with either of the two boundary faults, for it must have been far beneath them. If it was connected with some other thrust fault, then that fault must be one that would reach the surface of the ground many miles to the south of the epicentre, the actual distance south depending on the inclination of the fault plane. To put it another way, had the earthquake been due to movement along either of these two boundary faults at a depth of say 20–40 miles, then the epicentre at the surface of the ground would have been many miles north of its actual position.[2]

As an alternative explanation, Middlemiss pointed to the change of load caused by the denudation of the mountains and deposition in the valleys, pointing to the Dhauladhar ridge being at about 16,000 feet, with the Kangra valley at about 3,500 feet at a distance of only six miles. But, as already pointed out, this factor of change of load cannot be regarded as of genetic significance. The forces which gave rise to the folding and uplift of the Himalayan range, and which may still be in operation, are to be regarded as the originating cause of the earthquake, and to bring in this question of change of load seems to be an unnecessary complication of the problem. Moreover, the presence of high topographical relief, with its accompanying change of load consequent upon denudation, is a common feature in areas that are unaffected by earthquakes. The prime consideration is the close connection between the main earthquake belts and recent or present-day folding and mountain

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[1] There has been some confusion over the use of the term 'main boundary fault'. The original 'main boundary fault' of H. B. Medlicott and R. D. Oldham was the fault separating the Siwaliks from the older Tertiary rocks. There is also a second boundary fault of similar importance separating the Tertiary from the pre-Tertiary rocks. Middlemiss in both his accounts, and also in his maps accompanying them, applies the term to the latter fault; but in his second account he states that the epicentre was nearest to the fault separating the Siwaliks from the older Tertiary rocks.

[2] Since writing the above I find that so long ago as 1909 R. D. Oldham pointed out that the Kangra earthquake seemed to have had no connection with the main boundary fault. See *Quart. Jour. Geol. Soc.*, 65, p. 13, 1909.

formation, and factors such as change of load can have little connection with the problem.

The North Bihar earthquake differed from the Kangra earthquake in that its main epicentre was located some distance to the south of the Himalayas, well out in the Gangetic plain. Its effects were studied in the field by Mr. D. N. Wadia, Dr. J. A. Dunn, Mr. J. B. Auden, and Mr. A. M. N. Ghosh of the Geological Survey of India,[1] while the seismological data have been studied by Dr. S. K. Banerji and Dr. S. C. Roy.[2] The former authors have already published a valuable preliminary report, and their final memoir on the subject will be read with much interest.

The earthquake appears to have affected much the same area as the less severe earthquake of 1833, which also damaged Katmandu. The field investigations carried out by the above authors have brought to light several interesting facts. Regarding the local epicentre around Katmandu in Nepal, while there was undoubtedly an increase of intensity in this area, Mr. Auden was unable to find evidence of movement along any of the three main thrust faults that occur in this section of the Himalaya. It was therefore concluded 'that the movements responsible for the earthquake originated further south, along thrust planes that are now concealed by the Gangetic alluvium'.

As regards the effects of the earthquake in the plains, two points were clearly brought out. The approximate coincidence of a 'slump belt', in which the alluvium received a severe shaking in a vertical direction, with the main zone of damage, is confirmation of the view that the earthquake originated in some line of weakness immediately below the epicentral area. The elongation of the epicentral zone in a direction parallel to the great thrusts of the Himalaya 50 miles to the north, suggests a connection with thrusts of similar origin in a zone parallel to and south of the Himalayan thrusts. Dr. Dunn has further suggested that a single fracture plane alone may not have been the cause, but that a zone of the earth's crust of considerable width, including several fractures, parallel or in echelon, may have been involved. This seems to agree with Dr. Banerji's conclusion that, judging by the total energy produced, namely slightly greater than 10^{22} ergs, the focus of the earthquake must have covered a wide volume.[3]

On the assumption that the earthquake originated in movement along a fault or zone of faults, the question arises, did the

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1 *Rec. Geol. Surv. India*, LXVIII, p. 177, (1934).

2 *Current Science*, II, p. 326, (1934) : and *op. cit.*, p. 419, (1934).

3 Dr. Harold Jeffreys, however, is of opinion that the actual focus of an earthquake is probably always a small region, not more than a few kilometers in linear dimensions at the most. This he concludes from the fact that it is possible to separate the later phases on the seismograms so clearly. See 'Earthquakes and Mountains', p. 55, (1935).

movement take place within the alluvium, or within a possible extension southwards of Tertiary rocks beneath the alluvium, or within the Archaean floor of the Gangetic trough. It is here that the seismological evidence may help, by indicating the depth of focus of the earthquake. Dr. Roy calculated that the focal depth was about 13 kms.; but Dr. Banerji concluded that in view of the great preponderance of surface waves the earthquake must have had a shallow focus, that is in so far as it is possible to give a depth to a focus that may have had very considerable volume. It is to be hoped that the further study of the seismological data will throw more light on this point.[1]

A certain amount of emphasis has been laid by some writers on the fact that the epicentre occurs in the area of underload that marks the site of the Gangetic trough. Dr. J. de Graaff Hunter has in fact suggested that such 'regions of great loading anomaly must cause very great stress differences in the earth's crust which supports them. The region of underload and the amount of underloading are very much of the order which has been estimated by Dr. H. Jeffreys to be sufficient to cause fracture in the lithosphere'.[2] Nevertheless, similarly large areas of negative anomaly are found in regions where no important earthquakes occur, for example in Mysore, and the anomaly, therefore, cannot be regarded as the cause of the earthquake. On the other hand, Col. E. A. Glennie, in emphasizing that this deficiency of density cannot be accounted for by the low density of the alluvium of the Ganges valley unless this were about 50,000 feet thick, which is extremely improbable, has concluded that the anomalies are due to a much deeper seated phenomenon, whereby the granite, basalt and dunite layers of the earth's crust have been depressed over this area, and elevated further south. I do not intend to discuss this interesting speculation further here, but only to emphasize that the underload, and the stress differences that it involves, should not be regarded as the cause of the earthquake, but rather that the underload and the earthquake should be regarded as different phenomena resulting from some much more fundamental cause.

Before concluding this section I should like to refer briefly to the initiation of a line of investigation that promises to yield important information. To the geologist, the large area covered by the Gangetic alluvium is a *terra incognita* so far as the structure of the older rocks beneath the alluvium is concerned. And since it is in this area that the epicentre of the North Bihar earthquake was located, any information that can be obtained regarding the underground structure is likely to be of great value. It was therefore decided that the Geodetic Branch of the Survey

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[1] For a symposium on the origin of this earthquake, see *Proc. Ind. Sci. Congr.*, p. 452, (1935).

[2] *Nature*, CXXXIII, p. 236, (1934).

of India should undertake a preliminary investigation in North Bihar, using gravimetric and magnetic methods independently over the same line of country. The line chosen for the traverse was from the Nepal boundary due south, passing just west of Motihari, that is approximately down the 84°55′ meridian.[2] The results that have been obtained are most promising, and are shown in figure 2. For permission to reproduce this figure

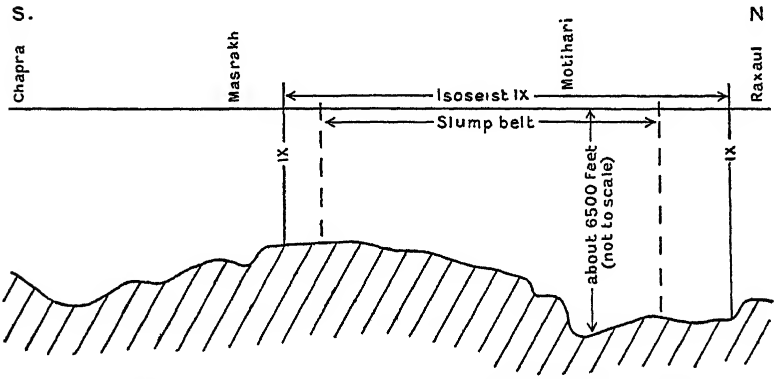

FIG. 2. Vertical section across the northern half of the Gangetic trough.

from the Geodetic Report for 1935 I am much indebted to Brigadier H. J. Couchman, Surveyor General of India. In this figure the underground contour of the floor of the alluvium is indicated in section, and the limits of isoseist IX and of the slump belt are also shown. It is obvious that a full interpretation cannot be made from a single traverse; but the results so far achieved suggest that the work is likely to be fruitful. The most striking feature is the dip in the contour below Motihari. The line traversed did not cut isoseist X, but the axis of the epicentral area continued west would pass through Motihari. One hesitates to offer any interpretation of this feature, but the first impression is the similarity of the area to the Assam region, the feature south of Motihari corresponding to the northern edge of the Assam range, and the depressed area to the valley of the Brahmaputra. Since this dip in the contour is roughly in a line with the zone of weakness deduced by Mr. E. R. Gee as existing along the northern edge of the Assam range, and as having been responsible for the Dhubri earthquake of 1930, it is possible that it represents the line of a fault or zone of faults. It may be that the nature of this depression can never be settled; but the results so far obtained are highly suggestive, and it

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[2] *Geodetic Report for 1935*, p. 59, (1936).

is to be hoped that further work will be done along parallel traverses.

4. Assam.

From a structural point of view Assam is probably the most interesting province in India, while its unfortunate susceptibility to earthquakes has given it a notoriety that has attracted much attention from seismologists. It is impossible within the compass of this section to give more than a mere outline of the structural features, and an attempt will only be made to bring out the salient points. For much of what follows I am indebted to Dr. C. S. Fox, who is now engaged in a resurvey of the Assam Range. I should also acknowledge the valuable information that has been provided of late by the Geological Department of the Burmah Oil Company, some of which has recently been summarized by Mr. Percy Evans.[1]

The map forming figure 1, which shows the trend lines of the mountain folds, the alluvium filled troughs, and the fractured continental fragments forming the Assam range, gives the main elements of the structure of the Assam region. As La Touche showed long ago, the eastern Himalayas have much the same structure as the rest of this great range, and the evidence for overfolding and thrusting from the north, whereby older strata have been forced over younger, is perfectly clear.

Facing the Himalayas, on the south-east side of the upper Brahmaputra valley, there occur the Patkai and Naga hills, the structure of which has been established by the geologists of the Burmah Oil Company as large scale imbricated overthrusting from the south-east. Thus, as Dr. Fox points out, the upper Assam valley is a fine example of 'ramp valley' structure, being a strip of the earth's crust held so tightly, as in the jaws of a vice, that it is being depressed. It is unfortunate that the structure of the north-eastern end of this great hairpin bend in the alignment of the mountains is practically unknown, but it is a region almost impossible of access.

Traced to the south, the Naga hill ranges continue through Manipur and the Lushai hills into the Arakan Yoma of Burma, with trend lines running nearly north and south. To the west of this line the ranges of Chittagong and Hill Tippera also trend north and south, and their northern spurs continue to within a few miles of the southern scarp of the Khasi and Jaintia hills. This southern scarp involves a strip of folded rocks whose axis trends east and west, i.e., at right angles to the trend lines of the ranges immediately to the south.

Further north-east, the junction between the trend lines of the Assam range and those of the Manipur and Naga hills is marked by a great reversed fault, which runs in a south-west

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[1] *Trans. Min. Geol. Inst. Ind.*, XXVII, p. 155, (1933).

direction near Haflong, becoming a normal fault at the foot of the Jaintia hills. Further west still its place is taken by a great monoclinal fold along the southern margin of the Khasi hills, while a reversed fault is again developed (in the opposite direction) in the Garo hills.

The Archaean block of the Assam range slopes gently northwards, and there is little doubt that it underlies the entire Brahmaputra valley of Assam, with a relatively thin covering of alluvium. According to Dr. Fox, this fragment of Peninsular India is rent by cross-faults trending north and south, which have sliced the block into fragments that have been pushed southwards in echelon. One of these faults is the Chedrang fault that was formed during the great earthquake of 1897, referred to again below.

I will now refer briefly to three earthquakes that have visited this area, those of 1869, 1889, and 1930. Their epicentres are shown on Plate 3.

The Cachar earthquake of 1869 was investigated by Thomas Oldham, but the memoir on the earthquake was written in the main by his son R. D. Oldham.[1] Originating near the north-eastern border of the Assam range, the earthquake was chiefly remarkable for the earth-fissures and sand craters that accompanied it, the first rational explanation of which was given in this memoir. This was a feature that was to become so tragically manifest during the 1897 earthquake, and again in the North Bihar earthquake of 1934. Regarding the origin of the shock, the state of the country at that time and the difficulties of transport rendered a complete examination of the effects of the earthquake impossible. Consequently it is difficult to offer an explanation of the shock, nor did Oldham attempt any in his memoir. It may be that, situated along the north-eastern border of the range, it had a similar origin to the Dhubri earthquake of 1930, which was located along the north-western border of the range.

The great Assam earthquake of 1897, possibly the most severe that has occurred anywhere within historic times, was studied in great detail by R. D. Oldham. His original account fills a bulky volume,[2] while a further consideration of the data was published by him in 1926.[3] The earthquake was remarkable in many respects. The suddenness with which it began ; the extreme intensity of the surface vibrations over a large area ; the variations in the intensity from place to place ; the number of faults along which movement took place, including a maximum throw of 35 feet in the case of the Chedrang fault ; the general upheaval of the country ; and the remarkable

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[1] *Mem. Geol. Surv. Ind.*, XIX, (1882).
[2] *Op. cit.*, XXIX, (1900).
[3] *Op. cit.*, XLVI, Pt. 2, (1926).

series of aftershocks, all combined to demonstrate the complicated nature of the earthquake.

It might be suggested that the movement along the Chedrang fault, which could be traced for 12 miles, with a variable upthrow on the east side, was sufficient in itself to account for the whole disturbance. But, as Oldham pointed out, the movement along this fault, though by far the most conspicuous, was but a small fraction of the total of the permanent changes that accompanied the earthquake. Moreover, these changes were not confined to one spot or one line, but extended over the northern part of the Assam range for a distance of 100 miles from east to west, an area in which the earthquake was everywhere of great to extreme violence. To account for all these facts, Oldham concluded that the focus must have had a large volume. In his earlier memoir he suggested that the phenomena could be accounted for by movement along a nearly horizontal thrust plane which nowhere reached the surface, accompanied by more steeply inclined secondary thrust planes which reached the surface as actual faults, much after the style of the imbricate structure of the North-West Highlands of Scotland, which had just then received prominence in geological literature. In his second memoir, however, published 27 years later, he brought forward an entirely new hypothesis. This was to a large extent due to the study that he had made of the effects of the Californian earthquake of 1906, from which he concluded that the movement along the San Andreas and other faults was not the cause of the earthquake but merely one of its superficial aspects.[1] He postulated a deeper seated cause, to which he applied the term 'bathyseism', and concluded that the earthquake was not the result of a slowly accumulating strain suddenly relieved by movement along the faults, but of one rapidly developed by the bathyseism, whatever the nature of that might have been.

Applying this hypothesis to the Assam earthquake, Oldham offered an explanation of the nature and action of the deep-seated bathyseism by appealing to a theory put forward by Sir Lewis Fermor, whereby it is postulated that there is a deep-seated shell within the earth composed of the dense rock eclogite, which may from time to time change abruptly to a magma of the same composition but greater volume, a change that would probably be exothermic in nature and so spread rapidly through a large volume of matter that was near the critical balance of temperature and pressure at which change takes place.[2] This theory has already been referred to, and will not be discussed further here. The point that is mainly at issue is the fundamental problem of whether earthquakes origi-

[1] *Quart. Journ. Geol. Soc.*, LXV, p. 1, (1909).
[2] *Mem. Geol. Surv. Ind.*, XLVI, Pt. 2, p 53, (1926).

nate through movements along faults, or whether the origin is much more deeply seated, and the faults merely a superficial effect. In the case of the Assam earthquake, the former explanation seems the more probable. But in the absence of detailed seismograms, it is unlikely that we shall ever get any nearer to a solution of the origin of the earthquake, though Oldham should at least get the credit for having raised the issue of this fundamental problem.

There still remains for brief consideration the Dhubri earthquake of 1930, described by Mr. E. R. Gee.[1] It was located near the north-western end of the Assam range and the adjoining valley of the Brahmaputra river. According to Gee, while the main shock was located as above, several of the more severe aftershocks occurred further up the Brahmaputra valley along the northern border of the range. He is of opinion that lines of fracture have been developed along this northern border as a result of the advance of the Himalayas towards the south, and that a definite zone of structural weakness exists here. If this is so, then the Cachar earthquake of 1869, located further east, probably originated in a similar way.

Recently Dr. C. Davison has made a study of the earthquakes recorded by a simple pendulum at Shillong between the years 1903 to 1931.[2] It is possible that the data require further statistical analysis, but the conclusion that Dr. Davison comes to is rather disquieting. He writes as follows: 'Thus the Shillong earthquakes ceased to be true after-shocks of the 1897 earthquake after about ten years; the next year or two formed a transitional interval; but, from 1909 onwards, the crust-movements of Assam resumed their original character and may in course of time end in another great destructive earthquake'. It is possible, however, that the Dhubri earthquake of 1930, which was felt over an area of about 350,000 square miles, was the earthquake indicated by the records as being imminent.

I have purposely refrained in this account of Assam earthquakes from discussing the origin of those shocks that have been located in the plains south and south-west of the Assam range, such as the Bengal earthquake of 1885, and the Srimangal earthquake of 1918. The nature of this part of the Gangetic plain and its actual origin are still a matter of some controversy, and to discuss the matter here would serve no useful purpose. But from the brief review that has been given above of earthquake activity in Assam, it seems clear that the relation between the geological structure of this part of the earthquake belt and the incidence of earthquakes is at present rather difficult to decipher. As already shown, the structure of this area, in which a frag-

[1] *Mem. Geol. Surv. Ind.*, LXV, Pt. 1, (1934).
[2] *Rec. Geol. Surv. Ind.*, LXIX, p. 184, (1935).

ment of Peninsular India has got caught in the Tertiary folds advancing from both the north and the east, like a nut in a nut-cracker, is very complicated, and the origin of the resulting earthquakes must also be complicated. It is possible that Oldham over-emphasised the deep-seated nature of the 1897 earthquake, and that it can be adequately accounted for by the known structure.

5. Burma.

Coming now to the last of the five areas of seismic activity that I have selected for discussion, we find once more that the distribution of the earthquakes is closely related to the geological structure of the country. I have no personal knowledge of the geology of Burma, and I am glad to acknowledge the help derived from discussions with my colleague Mr. V. P. Sondhi.

Geologically Burma may be divided into three main structural units, aligned north and south. On the east is the Shan plateau, consisting of Pre-Cambrian, Palaeozoic and Mesozoic rocks, folded and uplifted into its present form in early Tertiary and later times. In the centre is the Tertiary basin of the Irrawaddy valley, consisting in the main of younger Tertiary rocks, folded and faulted in late Tertiary times. A subsidiary unit within this belt is the Pegu Yoma, a range of low hills extending from Pegu to near Mount Popa. It is an anticline within the main synclinorium. On the west is the fold range of the Arakan Yoma, consisting of Cretaceous and early Tertiary rocks. It was folded in late Mesozoic and early Tertiary times, and is continued southwards, after a break, through the Andaman and Nicobar Islands. The sketch map given in figure 3 shows these three main units. They are separated from each other by zones of faulting, though the exact nature of the faulting is not yet clearly understood. There is little doubt, however, that the central Tertiary belt is to be regarded as a down sunken trough or synclinorium, the sinking and folding of which were more or less simultaneous. Thus the faulting along the western margin of the Shan plateau seems to be middle Irrawadian (Pliocene) in age, which is approximately the same age as the folding of the Pegu Yoma. The faulting that separates the central Tertiary belt from the Arakan Yoma has not yet been studied in detail, but it is probably of late Tertiary age.

A quarter of a century ago T. H. D. La Touche drew attention to the similarity between the Himalayan and Burmese arcs of folding.[1] He showed that from the geological point of view the Shan plateau corresponded to the Tibetan plateau; the fringe of hills that border the western side of the Shan plateau to the main Himalayan range; the central belt of the Tertiary

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[1] *Mem. Geol. Surv. Ind.*, XXXIX, Pt. 2, p. 357, (1913).

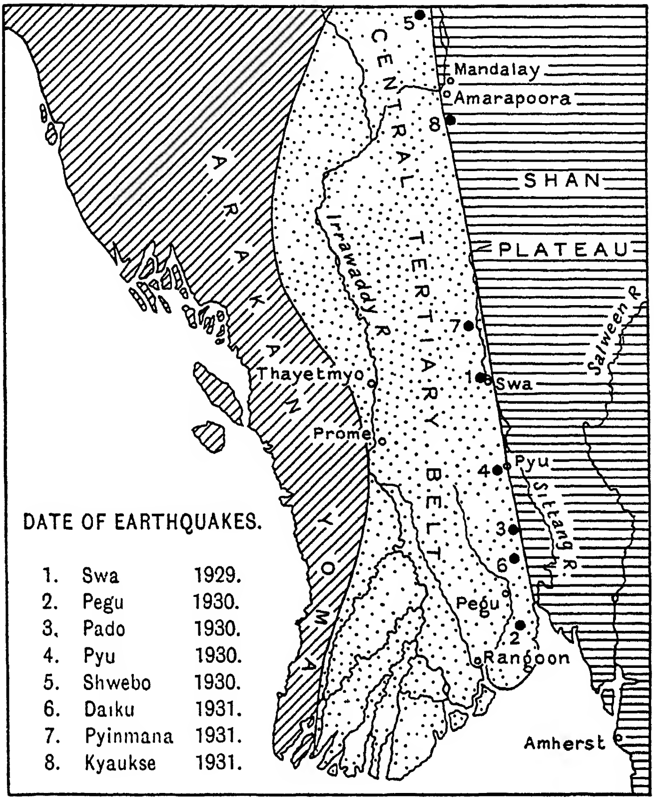

Fig. 3. Map of Burma, showing the main structural elements, and the epicentres of recent earthquakes (the latter after J. C. Brown).

(Scale, 1 inch = 128 miles).

rocks in Burma to the younger Tertiary rocks of the sub-Himalayan foot-hills and *duns*; the Arakan Yoma to the Siwalik Hills; and, in front of all, the Bay of Bengal and the swamps of Sylhet and Cachar to the Indo-Gangetic alluvium. And although the second comparison given above can hardly be maintained, there is undoubtedly a close resemblance between the structural elements of the two areas.

When we come to examine the distribution of the epicentres of Burmese earthquakes, we find significantly that they are mostly closely related in position to the two main zones of faulting referred to above, bounding the central Tertiary basin on either side. It is unfortunate that, as is the case with other early Indian earthquakes, we are unable to determine the exact

location of the epicentres of early Burmese earthquakes. Regarding two such earthquakes, however, we can be tolerably certain of their location. The great Burmese earthquake of 1858 was most severely felt around Thayetmyo and Prome. Judging by the intensity of the shock felt at other places, the epicentre was probably a little west of these two places, and this suggests that it was located close to the zone of faulting along the east side of the Arakan Yoma, and it has been shown thus on the accompanying earthquake map of India forming Plate 3. Another great destructive earthquake occurred in 1839, and was felt over the whole of Burma, reaching its greatest intensity at Ava and Amarapoora, near Mandalay. Amarapoora was then the Capital of the Burmese kingdom, but as a result of its destruction in this earthquake, the capital was moved to Mandalay. The epicentre of this earthquake must therefore have been located close to the line of faulting that bounds the western side of the Shan plateau.

Thus the two greatest Burmese earthquakes known to us in early times were located along these two zones of faulting bordering the central Tertiary belt.

Coming now to more recent times, and leaving aside for the moment the earthquake of 1912, referred to later, a remarkable series of earthquakes took place during the years 1929-31. These have been described in detail by Dr. J. Coggin Brown and Mr. P. Leicester, and their geological implication discussed by the former author.[1] Their distribution as determined by Coggin Brown is shown on the accompanying map forming figure 3. The most striking feature brought out by this map is the linear distribution of the epicentres, a feature that clearly cannot be accidental and suggests a fault or line of faults. Examination of the position of the epicentres shows that they are located close to the boundary of the Shan plateau, except at their southern end, where they approach more closely to the eastern flank of the Pegu Yoma. The exact position of the faulted boundary of the Shan plateau at its southern end is unfortunately obscured by the alluvium of the Sittang valley, but it cannot be far east of the line of epicentres. Thus from their location it seems likely that this series of earthquakes were caused either by movement along the faulted boundary of the Shan plateau, or by a continuation of those movements which in the past compressed and elevated the Pegu Yoma. But in view of the fact that the line of epicentres extends some way beyond the northern end of the Pegu Yoma, though remaining close to the boundary of the Shan plateau, it seems likely that the former hypothesis is the correct one.

Coggin Brown cites evidence to show that there occurred a slight elevation of the country at the time of the Pegu earth-

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[1] *Mem. Geol. Surv. Ind.*, LXII, (1933).

quake, while he also discusses the possible instability of the land due to the increasing size of the deltas of the Irrawaddy and Sittang rivers, causing a growth of the land into the Gulf of Martaban.[1] It may be that this was a contributory cause in the case of the Pegu earthquake; but the fact that the line of epicentres extends right up to beyond Mandalay, and that they are parallel to the structural lines of the country, suggests that the earthquakes had their origin in some regional feature, which is parallel to, and therefore, closely connected with, the structural lines of the country. The balance of evidence is that this feature is the faulted boundary of the Shan plateau.

Considering now the Burmese earthquake of 1912, the position of which is shown on Plate 3, we have to deal with one that originated within the Shan plateau. It was the most severe that has occurred in Burma during the present century, being felt over an area of about 375,000 square miles. It has been described in detail by Coggin Brown, his conclusions on the origin of the earthquake being based on the field work of T. H. D. La Touche.[2] The disposition of the isoseismal lines of this earthquake, as determined by Coggin Brown, show that the epicentre of the earthquake was located close to the Kyaukkyan fault, one of a series of faults within the Shan plateau, the major axis of the inner isoseismal line coinciding very nearly with this fault. While no fresh surface displacement was apparent along the fault as a result of the shocks, the railway line was twisted close to the point where it crosses the fracture.

According to La Touche the forces that affected the Shan plateau during Tertiary times were, in order of occurrence: (1) regular folding, accompanied by overthrusts and reversed faults; and (2) vertical faults giving rise to subsidences that may represent an easing off of the compressive forces. It is evidently this later type of movement which must have been responsible for the 1912 earthquake.

This concludes my discussion of the structure of the earthquake belt of India. In it I have endeavoured to demonstrate the close connection that exists between the geological structure of the country and the distribution of earthquakes, and to show that the one follows logically from the other. And though there is still a great deal to learn before we can hope to offer a complete explanation of the phenomena, the advance that has so far been made is, I think, not inconsiderable.

VI. THE FUTURE.

Before considering the future, it will be profitable to pause for a moment and review what has been learnt from the past.

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[1] *Rec. Geol. Surv. Ind.*, LXV, p. 262, (1932).
[2] *Mem. Geol. Surv. Ind.*, XLII, (1917).

We have an earthquake belt passing through India, which the records of the past show has been characterized by activity throughout almost its entire length at one time or another. During recent years activity has in the main been confined to three centres—Baluchistan, Assam, and Burma, with an occasional disastrous earthquake elsewhere. This activity has been responsible for the loss of thousands of lives, the incidence of much misery, and the destruction of valuable property and records. The geological causes of this evil are well known, and it is recognized that the malady is chronic and must continue in the future. The question arises, therefore, by what means is it possible to ameliorate or to forestall the worst effects of the disease.

The researches of palaeontologists show us that when a group of animals is subjected to conditions that are inimical to its mode of life, it must either adapt itself to the changed conditions or perish. The more flexible groups are able to make this change, but other groups, too sluggish or too specialized, are unable to adapt themselves, and they ultimately die out. This disease of earthquake incidence is experienced by many countries through which the present earthquake belts pass, and in most cases an attempt has been made by the country to adapt itself to, or perhaps I should say to react against, the unfortunate malady. In India, however, until very recently, practically no endeavour has been made to this end. Is this country, then, to be penalized to the same extent as those groups of animals which, through inability to adapt themselves, have been severely handicapped in the progress of life ? That this analogy is not entirely far-fetched may be shown by considering two possible cases. Supposing that during time of world war one of the great military outposts on the frontiers of India was destroyed by earthquake, its communications with the rest of India cut off, and the mobility of its garrison incapacitated, as happened at Quetta in 1935. Or supposing that one of the great commercial cities of India were laid in ruins, its business activities paralyzed, its social amenities destroyed, and its records, whether in finance or research, lost for ever, as happened at Tokio and Yokohama in 1923. Would not such disasters prove not only unfortunate to the places concerned, but a serious blow to the progress of India in general ? If, therefore, it be recognized that a passive attitude to such conditions is inimical to the best interests of this country, in what direction should action be taken ?

In considering this problem there would appear to be two lines of approach : (1) to investigate the possibilities of predicting the incidence of earthquakes, both with regard to place and time ; (2) to recognize the inevitability of earthquakes within the danger zone, and to adopt measures of protection against them in accordance with principles that are now well known. No

doubt to the lay mind the former would appear the more spectacular, but I am convinced that it is the latter that would in the long run be the more effective. Moreover, any warning that might be given of the arrival of an earthquake, while it would certainly give people an opportunity of escape, would not prevent any of the great material damage that accompanies severe earthquakes in India. This method alone, therefore, would never provide more than a partial solution of the problem ; and it is clear that both courses should be pursued, for the two are complementary, and together provide the fullest approach to a solution of the problem.

It has to be admitted at the outset that practically no research has so far been done in India along either of these lines. This is rather remarkable in view of the impetus given to the study of earthquakes by R. D. Oldham at the beginning of the present century. It may be that the long period of comparative earthquake quiescence experienced in India between 1905 and 1927 has been responsible for the loss of interest. However that may be, now that attention has been aroused once more by the recent succession of severe earthquakes, it is to be hoped that this country may once again take its place in the forefront of seismological research.

This lag in the progress of research in India is only too evident when a comparison is made with what has been done in Japan and in the United States of America. In Japan there are 105 seismological observatories. The Imperial University has a special seismological department, and maintains 25 instruments of different types in continuous action in Tokyo itself, while there are also a large number of trained seismologists. In the United States there are 42 seismological observatories, and also many trained workers. But in India, with its much larger area susceptible to earthquakes, there are only 6 seismological observatories, and not a single seismologist doing exclusively seismological work.[1] These organizations abroad have carried out most important research on the factors that govern the location of earthquakes, their time of incidence, and kindred problems ; and their future activities cannot fail to be of significance. In India nothing has so far been attempted on these lines, though this country has problems that are peculiar to itself, and that can only be solved by research conducted locally.

With regard to progress in the design of earthquake-resistant buildings, with the exception of a certain amount of construction that was undertaken by the North Western Railway, and also by the Army Department, after the Kangra earthquake of 1905, and again by the former after the Baluchistan earthquake of 1931, little advance has been made in this country, and it has

[1] For the above facts I am indebted to Dr. S. K. Banerji.

been left in the main to the Japanese engineers to carry out research on this problem.

The lessons to be learnt from experiments in earthquake-resisting buildings are now perfectly clear. Prior to the Japanese earthquake of 1923, a number of buildings had been constructed in Tokyo to withstand the effects of earthquakes, notably several designed by Dr. T. Naitu. During the great earthquake of 1923 these all escaped practically undamaged. It is not necessary, however, to go so far afield for examples. After the Baluchistan earthquake of 1931, the North Western Railway, with commendable foresight, erected new buildings in Quetta on earthquake-proof lines. During the Quetta earthquake of 1935 these buildings withstood the shock well, and demonstrated forcibly the value of this type of construction. On Plate 1 is given a photograph of one of these buildings, together with a photograph of the Dak Bungalow situated not a hundred yards away. Both photographs were taken after the earthquake. The lesson is plain for all to read, and shows how the use of simple earthquake-proof construction may contribute to the saving of life and property.

Having thus very briefly indicated the two lines of investigation that give most promise of fruitful results, I may now offer a few suggestions regarding the manner in which this work should be initiated. However little may have been done in the past regarding the development of seismological research in India, and in the construction of earthquake-resistant types of buildings, it is hoped that considerable advance will now be possible along both these lines.

With regard to seismological research, it seems clear that such work as is being done more or less independently by the Geological Survey of India, the Meteorological Department, and the Survey of India should be co-ordinated and expanded by developing a special seismological branch of one of the existing services. This might have its headquarters at Shillong, and would devote its time exclusively to seismological research. The scheme would involve the installation of a number of new seismographs to supplement those already in existence. These should be of two types, sensitive instruments of the kind at present existing, which are of value for recording strong distant shocks or weak local shocks, but are thrown out of action by strong local shocks; and less sensitive instruments which record strong motion, and which would be capable of surviving a severe shock and obtaining a complete record of it. Some of the problems that would receive attention from this new branch would include the determination of the exact velocity and acceleration in epicentral regions, thus providing data of use in designing earthquake-resistant buildings; the determination of the distribution and frequency of shocks in the earthquake zone, including a study of the minor shocks

that precede and follow major earthquakes; and the determination of the exact depths at which earthquakes originate. There should also be in reserve an organization that would act as a mobile unit immediately after an important earthquake, thus facilitating the accurate determination of the epicentres of the after-shocks. Such a scheme, if it could be started, would afford an excellent beginning, and provide a basis for future development and progress that might prove most fruitful in results, while its cost would be trivial in comparison with the damage done by a major earthquake.

Regarding now the means that should be taken to minimize the destructive effects of earthquakes, a start has been made by the Defence Department of the Government of India, which is considering the best method of making the buildings of cantonments situated within the earthquake zone more resistant to earthquakes than they are at present. The complete fulfilment of such a project is obviously impracticable on the grounds of the enormous cost that would be involved. But it is hoped that a beginning may be made with certain cantonments, which geodetic considerations suggest may be more dangerously placed than others. Even at these selected cantonments it will be impossible to embark on a programme of complete re-building. But a beginning is likely to be made by constructing new buildings on earthquake-proof lines, by paying special attention to buildings that are occupied at night-time, and by making egress from all buildings as easy as possible. In the case of Quetta, where the city was almost completely destroyed, and part of the cantonment badly damaged, it has already been decided to rebuild the whole cantonment with earthquake-resistant buildings, while a building code has been drawn up for the control of private building within the city. Thus a good start has been made by this Department of Government towards minimizing the effects of future earthquakes in certain places which are of importance to the defence of this country.

There still remains for consideration the far greater problem of improving the standard of buildings, both Government-owned and private, throughout the earthquake belt. Though the principles of earthquake-proof construction are now well known, and the requisite essentials of building codes fully understood from the experience gained in such countries as Japan, California, Italy and New Zealand, the great obstacle is that of cost. It is a difficulty, however, that has got to be faced; and while no very rapid improvement in the position can be expected, if all new construction and town planning in the more important cities within the earthquake belt be controlled by building codes, drawn up in accordance with local needs, and enforced by Provincial Governments and Local Boards, a start will have been made, which will itself have a cumulative effect. The mere sight of earthquake-resistant buildings being

constructed will arouse interest in the more intelligent citizen, and may perhaps encourage him to go and do likewise. And the rise of a new India, in which the people may live in safety, is a vision that is perhaps not entirely fanciful or impossible of fulfilment.

This brings me to my last point. My colleague Mr. Crookshank has suggested to me that an effort should be made to protect some of the architectural treasures of Northern India and Burma from the ravages of earthquakes. These masterpieces of a former culture have been handed down to us as a heritage of the past, and their loss would be irreparable. The Taj Mahal of Agra, the Golden Temple of Amritsar, the Shalimar of Lahore,—but why continue the list. Are these to suffer the fate that befell the Mosque of Sultan Ahmed at Ahmedabad, when it was destroyed in the Cutch earthquake of 1819, after standing for 450 years ; or the great Pagoda of Mingon at Amarapoora, that was overthrown by the Burmese earthquake of 1839 ? I would suggest that, just as St. Paul's Cathedral in London has recently been afforded protection against the vibrations of modern traffic, so may some of the priceless possessions of India be given protection against the vibrations of earthquakes. Thus may we hand on to the generations that are yet unborn some of the heritage that has been handed down to us from the past.

I have endeavoured in this address to bring out the relation between the geological structure of this country and the earthquakes that beset it ; and to show that earthquakes in India, so far from being inexplicable happenings beyond the understanding of man, are in reality a normal scientific phenomenon closely connected with the geological history of this country. The cost of repairing the damage done by a great earthquake may run into many crores of rupees, while the loss of life that may occur in one night of tragedy—20,000 at Kangra, 25,000 at Quetta—stirs the emotion as nothing else can. But knowledge is power, and if the knowledge that we are accumulating may ultimately give to us a complete means of combating this evil, and of overcoming the destructive forces of Nature, it will provide yet one more example of the great benefits that may be contributed by Science to the cause of human welfare.

APPENDIX.

Important Indian Earthquakes.[1]

1505. July 6th. A very severe earthquake felt from the United Provinces to Persia, causing great damage and loss of life around Kabul. Felt at Agra and Delhi.

1668. May. Delta of the Indus. Caused great damage.

1720. July 15th. Delhi. Damage was done to the walls of the fort and to many houses, cracks developed in the ground, and many lives were lost. Aftershocks were felt in Delhi for some weeks. The position of the epicentre is unknown.

1737. October 11th. Calcutta. Many houses thrown down, and the spire of the English church sank into the ground. Many ships were lost in the accompanying hurricane, and great loss of life occurred.

1762. April 2nd. Bengal and Burma. Felt most severely along the N.E. coast of the Bay of Bengal. Chittagong suffered severely, fissures opening in the ground, with fountains of water and sand.

1803. September 1st. United Provinces. Very severe at Muttra, many pukka buildings and the principal mosques being destroyed. Severe in the Simla and Kumaon hills. Damaged the Qutb Minar at Delhi. Felt at Calcutta.

1819. June 16th. Cutch. Felt over practically the whole of India, including Calcutta, and was one of the greatest of Indian earthquakes. 2,000 lives lost at Bhuj alone The great mosque of Sultan Ahmed at Ahmedabad destroyed after standing 450 years. An elevation of the ground for 80 miles on the north side of a fault running E.-W. temporarily dammed up a branch of the Indus. The Runn of Cutch flooded on the downthrow side of the fault.

1827. September. Lahore. Fort Kolitaran, near the city, destroyed, and 1,000 said to have perished.

1828. June 6th. Kashmir. Very severe. 1,000 reported killed. Fissures opened in the city. Followed by a great number of aftershocks for some months.

1833. August 26th. Bihar and Nepal. Felt over much the same area as the 1934 earthquake, though possibly not quite as severe.

1839. March 23rd. Burma. A very severe earthquake, felt over the whole of Burma, but most strongly around Mandalay. Amarapoora and Ava destroyed, and the stupendous temple of Mingon overthrown.

1842. February 19th. N. W. India. Felt from Kabul to Delhi, the epicentre probably near Jellalabad Jellalabad and Peshawar severely damaged.

1843. April 1st. Deccan. The only earthquake in Peninsular India known to have caused much damage. Epicentre near Bellary.

1852. January 24th. Upper Sind. Fort of Kahan ruined, and 350 killed. Severe but local.

1858. August 24th. Burma. Very severe, especially around Thayetmyo and Prome. Felt in Bengal. Sympathetic shocks in Madras and Bombay.

1869. January 10th. Assam (Cachar). Felt over an area of 250,000 square miles, the epicentre being on the north-east side of the Shillong plateau. Earth fissures and sand craters very abundant, and their origin discussed for the first time by T. Oldham.[2]

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[1] This list is based mainly on T. Oldham's catalogue.

[2] *Mem. Geol. Surv. Ind.*, XIX, Pt. 1, (1882).

1881. December 31st. Bay of Bengal. Felt over an area of 2,000,000 square miles mostly sea.[1]

1885. May 30th. Kashmir. Felt over an area of 110,000 square miles, the epicentre being a few miles west of Srinagar. About 3,000 lives lost.[2]

1885. July 14th. Bengal. Felt over an area of 230,000 square miles. Epicentre north-west of Dacca.[3]

1892. December 20th. Chaman, Baluchistan. Associated with a fault running N.N.E. along the western side of the hills. As a result of the earthquake the country west of the fault subsided a foot, and moved bodily 2½ feet southwards.[4]

1897. June 12th. Assam. Probably the greatest earthquake that has occurred anywhere during historic times. Felt over an area of 1,750,000 square miles, with the epicentre in the Shillong plateau. Exhaustively studied by R. D. Oldham, who suggested a complicated origin for it. Destruction of stone buildings almost universal in Shillong, Goalpara, Gauhati, Nowgong and Sylhet. Calcutta seriously affected. About 1,600 lives lost. Followed by a great train of aftershocks.[5]

1905. April 4th. Kangra. Felt over an area of 1,625,000 square miles. 20,000 lives lost. Kangra, Dharmsala and neighbouring places completely ruined. Origin attributed by C. S. Middlemiss to movement along one of the Himalayan reversed faults. at considerable depth.[6]

1909. October 21st. Baluchistan (Kachhi). Epicentre located on the alluvial plain; very elongated, aligned N.W.-S.E. 231 lives lost.[7]

1912. May 23rd. Burma. Felt over an area of 375,000 square miles. Epicentre located close to the Kyaukkyan fault on the Shan plateau, north-east of Mandalay.[8]

1918. July 8th. Srimangal (Assam). Many tea estates ruined. Epicentre 3½ miles south of Srimangal on an alluvial tract. Felt over an area of about 800,000 square miles. Sympathetic shocks off the Madras and Arakan coast. Re-levelling suggests that the earthquake was due to subsidence along the southern side of a normal fault cutting the rocks below the alluvium.[9]

1929. February 1st. North-west Himalaya. Epicentre about 25 miles north-west of Abbottabad. Of interest as being a deep focus earthquake, the depth calculated to be 160 kms.[10]

1930. May 5th. Pegu. Felt over a land area of 220,000 square miles. About 550 lives lost. The epicentre a long elongated tract S.S.E. of Pegu, aligned N.-S. Origin thought by J. Coggin Brown to be connected with the boundary faults of the Shan plateau, but perhaps intensified by increasing strains due to the growth of land into the Gulf of Martaban.[11]

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[1] R. D. Oldham, *Rec. Geol. Surv. Ind.*, XVII, p. 47, (1884).

[2] E. J. Jones, *op. cit.*, XVIII, p. 221, (1885).

[3] C. S. Middlemiss, *op. cit.*, XVIII, p. 200, (1885).

[4] C. L. Griesbach, *op. cit.*, XXVI, p. 57, (1893).

[5] *Mem. Geol. Surv. Ind.*, XXIX, (1900); and *op. cit.*, XLVI, Pt. 2, (1926).

[6] *Rec. Geol. Surv. Ind.*, XXXII, p. 258, (1905); and *Mem. Geol. Surv. Ind.*, XXXVIII, (1910).

[7] A. M. Heron, *Rec. Geol. Surv. Ind.*, XLI, p. 22, (1911).

[8] J. C. Brown, *Mem. Geol. Surv. Ind.*, XLII, Pt. 1, (1914).

[9] Murray Stuart, *Rec. Geol. Surv. Ind.*, XLIX, (1918); and *Mem. Geol. Surv. Ind.*, XLVI, Pt. 1, (1920).

[10] A. L. Coulson, *Rec. Geol. Surv. Ind.*, LXII, p. 279, (1929); and *op. cit.*, LXIII, p. 434, (1930). See also Jeffreys, H., 'Earthquakes and Mountains', p. 95, (1935).

[11] J. C. Brown and P. Leicester, *op. cit.*, LXV, p. 221, (1931).

1930. July 3rd. Dhubri, Assam. Epicentre at north-western end of the Garo Hills. Felt over an area of about 350,000 square miles. Origin thought by E. R. Gee to be mainly due to movement along a line of tectonic weakness at the margin of the Assam range, accentuated by the disturbance of isostatic equilibrium consequent upon the rapid denudation of the range.[1]

1931. August 27th. Mach, Baluchistan. Epicentre located down the Bolan pass and along the junction of the hills with the Kachhi plain. Felt over an area of 370,000 square miles. About 200 lives lost.[2]

1934. January 15th. North Bihar. One of the most severe in Indian history. Felt over an area of 1,900,000 square miles. At least 10,000 lives lost. Epicentre occupied a belt aligned W.N.W.—E.S.E. and running for some 80 miles from east of Motihari through Sitamarhi to Madhubani. Origin attributed by D. N. Wadia, J. A. Dunn, J. B. Auden and A. M. N. Ghosh to movement along a fault or series of faults below the alluvium.[3]

1935. May 31st. Quetta. Epicentre a narrow tract running 68 miles S.S.W. from Quetta through Mastung. Felt over an area of only 100,000 square miles, but very severe at the epicentre. About 25,000 lives lost, and great material damage in Quetta. Exact origin unknown, but the focus was probably shallow.[4]

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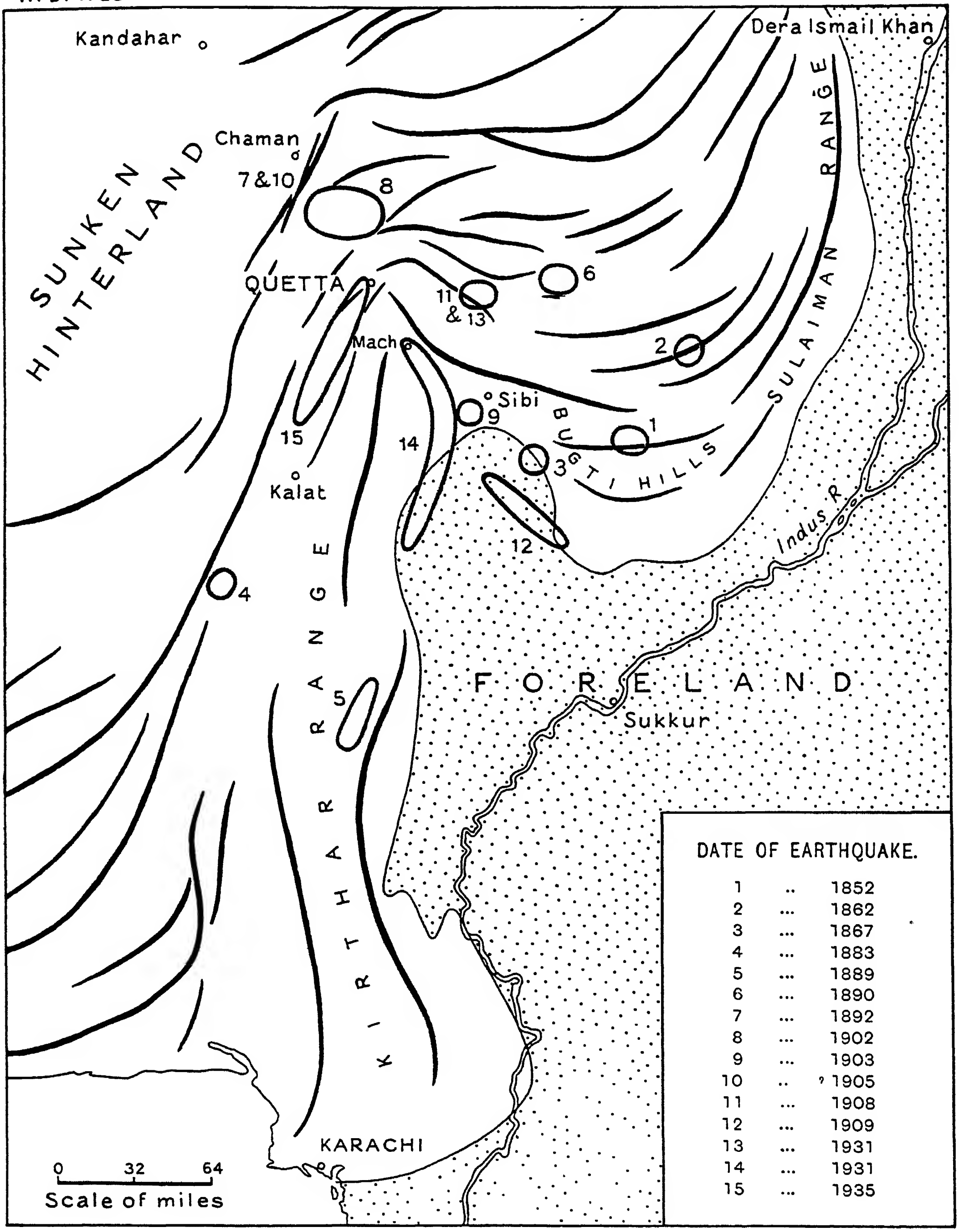
[1] *Mem. Geol. Surv. Ind.*, LXV, Pt. 1, (1934).
[2] W. D. West, *op. cit.*, LXVII, Pt. 1, (1934).
[3] *Rec. Geol. Surv. Ind.*, LXVIII, p. 177, (1934).
[4] W. D. West, *op. cit.*, LXIX, p. 203, (1935).

The Dak Bungalow, Lytton Road, Quetta. Completely ruined.

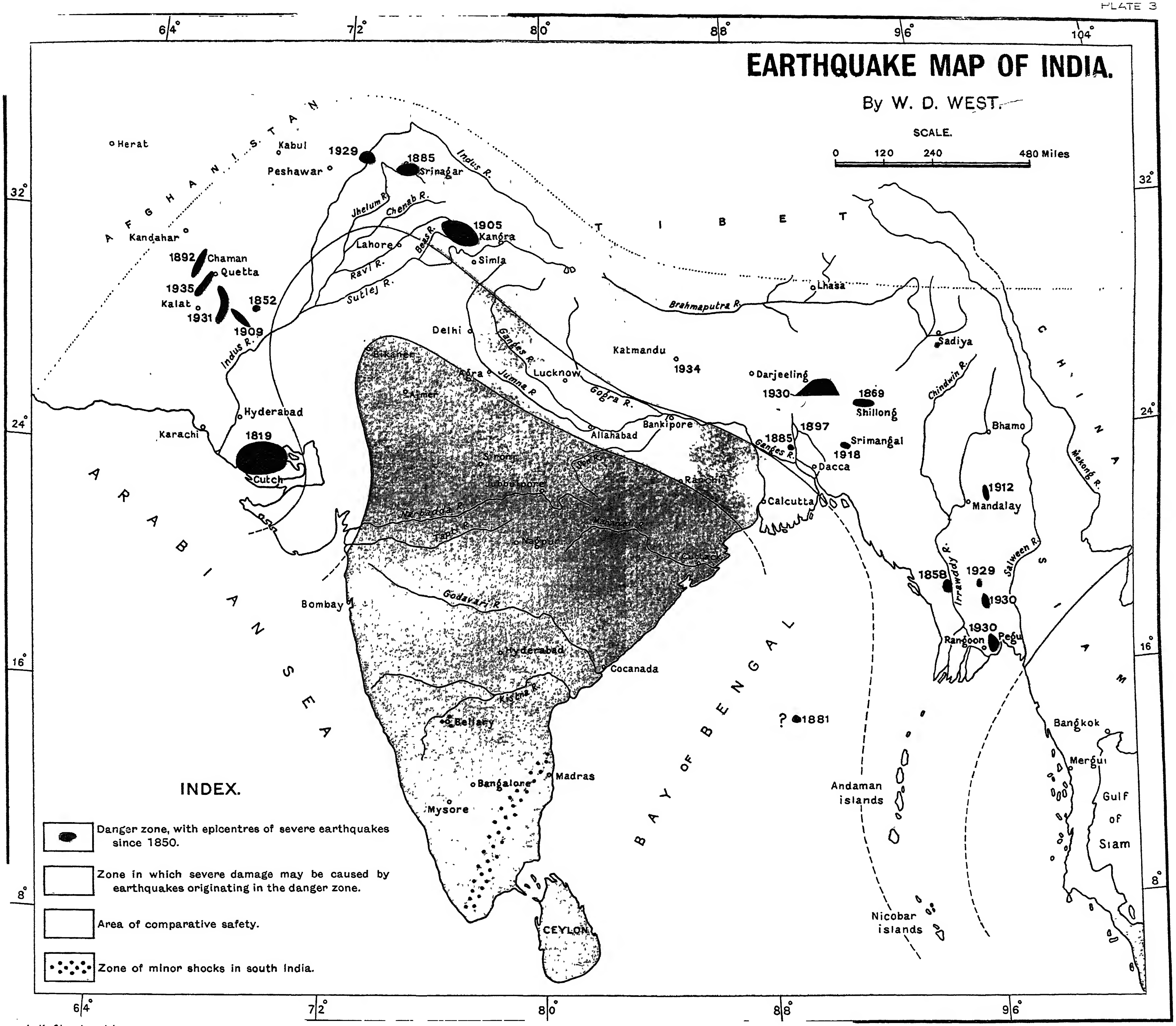
W. D. West, Photos. *By courtesy of D.G.S.I.*

A Railway earthquake-proof bungalow, Lytton Road, nearly opposite the Dak Bungalow.

THE VALUE OF SIMPLE EARTHQUAKE-PROOF CONSTRUCTION.



Map of Baluchistan and Sind, showing the alignment of the fold mountains and the epicentres of severe earthquakes since 1852.



A. K. Chandra, del.

SECTION OF GEOLOGY AND GEOGRAPHY

Abstracts

Opening Lecture

1. An outline of the geology of Hyderabad State.

KURSHID MIRZA, Hyderabad.

The geology of Hyderabad State is an epitome of the geology of Peninsular India. Within the limits of the State are met : the Dharwar series of rocks, the various members of the Peninsular crystalline complex, the Purana group, the coal bearing Gondwana formations, and the Deccan traps. Evidence of prehistoric mining activity for gold, copper, iron and diamonds is afforded by innumerable old workings studded in the respective geological formations.

The lecture will review the geological observations of early explorers (17th to 19th century), and the work done by the Geological Survey of India and the Hyderabad Geological Survey.

General

2. The Cretaceous volcanics of Astor-Burzil, Great Himalaya range, and their association with acid and basic plutonic intrusions.

D. N. WADIA, Calcutta.

A 12-mile wide synclinal belt of volcanic rocks—ash, tuffs, agglomerates, and basaltic lavas, with fossiliferous limestone intercalations, has been lately discovered by the writer, extending from Astor, through the head of the Burzil valley, to beyond Dras in Ladakh. The belt strides across the axis of the Great Himalayan range and shows complex folding. The best preserved fossils in the limestone are *Orbitolina*, belonging to two species, besides some fragmentary foraminifers, corals, and echinoids. The most interesting feature of the series is the intimate association of marine sediments with pyroclastic, volcanic and plutonic rocks. Dykes, stocks, and bosses of gabbro, pyroxenite, serpentine and peridotite have invaded the perfectly stratified ash and tuff beds, while hornblende-granite has permeated the whole series, the acid injections varying from thin veins to bosses several miles across. Its intrusion in *Orbitolina* limestone definitely dates the granite as post-Cretaceous.

It is probable that Eocene volcanics containing characteristic foraminifera are also associated with the Cretaceous, for Eocene fossils have been identified in Dras, 24 miles south-east along the strike of the Burzil syncline.

3. Pliocene and post-Pliocene denudation in Northern and Eastern India.

P. Evans *and* W. B. Metre, Digboi.

The evidence of mapping shows that in parts of the Punjab and Assam the denudation that has taken place since early Pliocene times—and mainly since a late stage in the Pliocene—has resulted in the removal of a stratigraphical thickness of at least 20,000–40,000 feet of beds, which is equivalent to a vertical thickness greatly exceeding this. It appears that the magnitude of this denudation has not yet received general recognition.

4. Notes on the geology of the neighbourhood of Dharwar, Bombay Presidency.

C. S. Pichamuthu, Bangalore.

The name 'Dharwar System' was given by Bruce Foote in 1888 to certain well-marked belts of schistose rocks occurring in the gneissic country. The name was chosen by him because of the typical development of these rocks in the Dharwar district, and especially in the neighbourhood of the town of Dharwar. No detailed account of the rocks was, however, given by Bruce Foote. Though considerable work has been done on the rocks of the Dharwar System in various parts of India, the Dharwar area itself has not been examined ever since Foote traversed this country nearly sixty years ago.

The author had an opportunity recently of studying the geology of the country between Dharwar and Hubli, and this paper gives an account of the petrographic characters of the rock types met with in this area. The rocks commonly found are variously coloured laminated shales, quartzites which are sometimes banded and sometimes quite pebbly, and haematite-quartzites in which the silica layers are often fine enough to be described as chert.

Comparisons are instituted between these rocks and those described elsewhere by the author from the Bababudan area, Mysore State, which is situated farther south in the same schist belt.

The paper is illustrated by photographs of outcrops and micro-sections, and by a geological sketch map of the area.

5. Structure contours of the X and XV seams of the Jharia coalfield.

S. K. Roy *and* K. K. Dutta, Dhanbad.

Based on the recently published geological maps of the Jharia coalfield by Dr. C. S. Fox, and on the personal observations of the senior author, innumerable geological sections across the Jharia coalfield have been drawn, and from these sections an effort has been made to prepare the structure contour maps of the important coal seams of this field. These maps are expected to be of some importance to the mine-owners and prospectors. The respective seams have also been plotted on the geological map so that their relation to their structure contours can be seen at a glance. The drawing of both latitude and longitude sections furnishes a check for accuracy.

6. Notes on pre-Trappean pebble beds in parts of Surapur taluk, Gulberga district, Hyderabad State.

C. Mahadevan, Hyderabad.

Underlying the Deccan trap outliers in Karianiguddâ (16° 26′: 76° 33′) and capping the shales of the Bhima series, extensive spreads of

pebbles of gneisses, quartzites, sandstones and limestones have been noted. The pebbles vary in size from an inch in diameter to about ten inches. They occur on an isolated group of hills at a height of about 350 feet from the present bed of the Kistna river, which runs roughly parallel to the group of hills about six miles further south. In the absence of evidence of upheaval of land in the area, it seems reasonable to assume that the pebbles (presumably of fluviatile origin) were deposited at their present level. They are distinctly pre-trappean in age, but are subsequent to the period of faulting that is noted in the Bhima series between Mallur (16° 27′: 76° 27′) and Wajal (16° 29′: 76° 33′). Their present perched position indicates the amount of denudation to which the area has been subjected.

7. On the unconsolidated earth underlying the Deccan traps in parts of the Gulberga district, Hyderabad State.

SYED KAZIM *and* C. MAHADEVAN, Hyderabad.

In parts of the Gulberga district, at the junction of the Deccan traps and the Bhima series of sedimentaries or Peninsular complex, some red, purple and white unconsolidated earth is frequently met with. The paper describes the origin and composition of this layer of earth which separates the Deccan traps from the lower geological formations.

8. The geology of Vengurla Peta, Bombay Presidency.

B. G. DESHPANDE, Poona.

The author has worked out the petrology of Vengurla Peta, an area of about 52 square miles lying between latitudes 15° 43′ and 16° north and longitudes 73° 30′ and 73° 43′ east in the Ratnagiri district of the Bombay Presidency. The rocks have not been studied in detail hitherto, only a brief description of the geology of the area appearing in the Ratnagiri District Gazetteer and in Memoir XII of the Geological Survey of India, by R. B. Foote.

The formations comprise hornblende-schists, biotite-schists, epidiorites, and massive granite-gneiss of Archæan age; sandstones, quartzites, breccias, shales, etc. of Cuddapah age; a dolerite dyke of Deccan trap age; and laterite and shore sands of recent origin.

The paper includes several chemical analyses of the granite-gneiss and quartzites, and detailed descriptions of the different rocks of the area. A geological map of the area on a scale of 1 inch = 1 mile accompanies the paper.

9. The applications of colour photography to geology.

P. EVANS, Digboi.

A small collection of coloured lantern slides will be shown to illustrate the possibilities of using the simpler methods of colour photography in geological work.

10. A cinematograph film of Quetta taken after the earthquake.

W. D. WEST, Calcutta.

A short film showing the destruction wrought by the earthquake in various parts of Quetta and at Mastung. The film was taken with the object of placing on permanent record the effects of the earthquake, and of showing the relation between the damage sustained by buildings and the nature of their construction. The great loss of life, the largest that has occurred in any Indian earthquake, was directly attributable to the inferior construction of the buildings.

Some of the features of the earthquake shown in the film include the complete destruction of Quetta city; the gradual decrease in the intensity of the damage towards the Cantonment and the Staff College; the way in which certain buildings recently constructed by the North Western Railway on earthquake-proof lines escaped undamaged; the rotation of monuments in the cemetery; the fissuring of the alluvium, and the associated buckling of the railway line; and the general destruction in Mastung.

Stratigraphy

11. Permo-Carboniferous limestone inliers in the outer Himalayas of Jammu, Kashmir.

D. N. WADIA, Calcutta.

A series of unfossiliferous dolomitic limestone outcrops occur in the Tertiary zone of Kotli, Jammu, in cores of denuded anticlines, forming conspicuous mountain masses. Their base is never exposed and their top is disconformably overlaid by Eocene Nummulitics. From their total lack of fossils and stratigraphical relationships, this thick, massive limestone had been designated 'Great limestone', and tacitly assumed to be of Kioto (Jurassic) age.

Recent work in the area by the present writer has revealed some stratigraphical data. At the faulted base of one of the anticlines near Sumlar, Kotli, the limestone is interstratified with black slaty tuffs, several hundred feet thick, belonging to the Agglomeratic Slate series, which in other parts of Kashmir is fossiliferous and of Uralian age. He has repeatedly observed this interstratification of Agglomeratic Slate and Panjal Trap with the Sirban limestone of Hazara, likewise unfossiliferous, and referred to as 'Infra-Trias', but which is now regarded, from its superposition on a (? Talchir) glacial boulder-bed as most probably Upper Carboniferous. There is close lithological similarity between the Sirban and Kotli limestones.

12. The occurrence of Cambrian beds in the Khasor range, North-West Frontier Province.

E. R. GEE, Calcutta.

During the recent geological survey of the cis-Indus Salt Range, new exposures of Cambrian beds were observed by the writer at two places in the western half of the range [see *Rec. Geol. Surv. Ind.*, Vol. LXVIII, Pt. 1, pp. 115–120, (1934)]. West of the Indus, in the trans-Indus ranges, the rocks consist mainly of Upper Palaeozoic, Mesozoic and Tertiary strata, but in the south-western end of the Khasor range near Saiduwali (32° 11′ 30″: 71° 2′), an inlier of older beds is met with. The Speckled Sandstone series, including the Talchir Boulder-bed (probably Upper Carboniferous) at the base, is underlain by a 'Gypseous group' regarding which conflicting opinions have been expressed. [See *Mem. Geol. Surv. Ind.*, Vol. XVII, Pt. 2, (1880); Vol. XL, Pt. 3, pp. 429–431, (1920).]

The sequence includes basal maroon sandstones followed by grey shales, shaley sandstones, and glauconitic sandstones. These pass up into light-coloured dolomites and dolomitic sandstones, above which are several hundred feet of gypsum with dolomite and bituminous shale, —the 'Gypseous group'. The overlying Talchir Boulder-bed includes numerous pebbles derived from this Gypseous group, and the writer is of the opinion that the strata exposed form a normal stratigraphical sequence correlating with the Salt Range sequence as follows :—

Age.	*Saiduwali inlier.*	*Salt Range.*
Probably Upper Carboniferous.	Talchir Boulder-bed.	Talchir Boulder-bed.
Cambrian.	Gypseous group.	Salt Pseudomorph beds.
	Dolomites, etc.	Magnesian Sandstones.
	Glauconitic sandstones, shales, etc.	Neobolus Shales.
Cambrian or Pre-Cambrian.	Maroon sandstones.	Purple Sandstones.

13. The geology and coal resources of the Saharjuri coalfield, S.P.

P. K. CHATTERJEE, Calcutta.

The Saharjuri coalfield is situated on the eastern side of the Adjai river in the Santal Parganas (originally in the Birbhum district, Bengal) and lies between latitudes 24° 5′ and 24° 10′ N. and longitude 86° 48′ and 86° 55′ E. The total area of this coalfield is only 12 sq. miles, of which the Barakars cover nearly 7 sq. miles.

A large fault passes through the field in a N.W.-S.E. direction. The rocks of the different formations (Archæans, Talchirs, Barakars and Intrusives) have been described. The Barakar sandstones contain carbonaceous shales and two coal seams which are being worked at present. The thickness of the seams varies between 18 and 25 ft. The nature and extent of the coal seams have been discussed in the paper. Laboratory investigations on the chemical characters show that the moisture content is high (4–6%), and that the ash varies between 10 and 30%. The other characters have been enumerated in the paper.

14. Chert beds and associated fossils in the Inter-trappeans near Gurmutkal in the Gulberga district, Hyderabad State.

SYED KAZIM, Hyderabad.

Inter-trappean chert beds intimately associated with silicified fossils of lamellibranchiata, brachiopoda, and gastropoda have been observed in proximity to Gurmutkal (16° 52′ : 77° 23′). The cherts occur as a distinct layer between the traps. The paper discusses the origin of the cherts and the horizon of these inter-trappean beds from the evidence of the fossils.

The observations in the field regarding the nature and occurrence of the chert beds suggest that they were mainly derived by the metasomatic replacement of the original calcareous deposits.

Palæontology

15. More algæ from the South Indian Cretaceous.

L. RAMA RAO, Bangalore.

Since the discovery of algæ in the rocks of the Niniyur group, a full account of which has been recently published (L. R. Rao and J. Pia : *Pal. Ind.*, N.S., Vol. XXI, No. 4, 1936), the author has examined several other rock types from the Upper Cretaceous beds of the Trichinopoly and Pondicherry areas. In a large number of these rocks, especially the limestones, numerous algæ have also been recognized. From these observations it will be seen that the algæ have played an important part in the formation of the limestones throughout the South Indian Cretaceous.

16. Echinoids from the Bagh beds.

G. W. Chiplonker, Benares.

The marine Cretaceous of the Narbada valley has been a subject of discussion ever since its discovery, and it has been variously assigned an age ranging from Albian to Senonian.

A detailed study of the echinoids from these beds shows that while some of the species bear affinities to Lower Cretaceous forms from Europe, north Africa, Palestine and Persia, others are closely related to Upper Cretaceous species from Persia and Algeria. Four out of five species of *Hemiaster* present in these beds belong to the groups *Proraster*, *Mecaster* and *Intergraster*, all of which appear first in the Cenomanian. The genus *Diplopodia*, which is not known to survive the Cenomanian, is represented in the Narbada valley by a species having distinct lower Cenomanian affinities. Considering the echinoid fauna as a whole, Lower Cenomanian seems to be the most appropriate age for this series of strata.

Mineralogy

17. Apatite, allanite and bismuthinite in barytes from Manbhum, Bihar.

J. A. Dunn *and* V. B. Rao, Calcutta.

Specimens from Malthole village (23° 26′ : 86° 26′), Manbhum, recently submitted to the Geological Survey laboratory, showed an interesting association of apatite, allanite and bismuthinite in barytes. The apatite is a green fluorine variety and occurs in perfectly formed hexagonal prisms. Other specimens show well-formed platy crystals of allanite in barytes. Both of these associations are unusual in nature. In some specimens intergrowths of galena and bismuthinite occur in barytes, and are replaced by cerussite and bismuthospharite respectively.

18. A note on the blue quartz of the charnockites of Pallavaram, near Madras.

N. Jayaraman, Bangalore.

A chemical analysis of this quartz reveals a small percentage of impurities such as Fe_2O_3, TiO_2, CaO and MgO. A description is given of the micro-sections of this mineral, along with micro-photographs which show the presence of acicular inclusions. It appears that the acicular inclusions are partly responsible for the colour exhibited by the mineral.

19. On the microcline-perthite from the mica-pegmatites of Nellore, Madras Presidency.

N. Jayaraman, Bangalore.

A detailed chemical and optical study of the ignited as well as the original specimens of this mineral was carried out with a view to correlating these data with the loss in colour as well as the change in properties exhibited by this mineral on heating. The results of the chemical analysis, and also micro-photographs of the sections of both ignited and non-ignited specimens, are given.

20. A graphical representation of the composition of some manganese minerals, including vredenburgite.

M. R. ANANTHANARAYANA IYER, Bangalore.

The minerals considered are those containing oxides of manganese and iron, and belonging to the three classes represented by (1) jacobsite, (2) bixbyite, and (3) vredenburgite. It is shown that by taking molecular percentages of Fe and Mn as abscissæ, and the percentages of available MnO_2 obtainable by chemical analysis as ordinates, the position of all possible minerals of the three classes may be represented by points in a graph. All such points of the two classes represented by jacobsite and bixbyite will lie on straight lines. The region between these two straight lines will contain the points representing minerals of the vredenburgite class. The results of some detailed experiments done with specimens of vredenburgite are discussed, and the inference is drawn that vredenburgite may be a definite compound. An explanation is suggested for the presence of hausmannite as an intergrowth lying along definite directions in some specimens of vredenburgite.

Petrology (Igneous)

21. The trend of differentiation of the acid magma in southern Bastar State, Central Provinces.

P. K. GHOSH, Calcutta.

The earliest phase of the acid intrusions is represented by a highly alkaline felspathic rock, aplitic to pegmatitic in character, and composed almost entirely of oligoclase and albite-oligoclase, varying amounts of potash felspars and quartz, with little or no ferro-magnesian minerals. This sodi-potassic type grades into a highly sodic type, the chief mineral constituent of which is albite-oilgoclase with a little anorthoclase. The latter magma at a subsequent stage shows almost complete elimination of potash, and gives rise to a rock composed of albite, abundant quartz and an alkali-rich blue hornblende. Thus the trend of differentiation of the initial felspathic magma, uninfluenced by contamination, seems to be in the direction of the gradual elimination of potash and increase in soda. Iron and magnesium show a concentration in the sodic rest-fluid.

The assimilation of the country-rock by the alkaline magma resulted in the production of hybrid rocks. Where the process of assimilation has been nearly complete, rocks resembling granite, granodiorite and even diorite have evolved. Transitions of the felspathic magma to the above-mentioned types, *via* injection gneisses and other hybrid rocks, can be actually observed on a small scale in the field.

The felspathic magma and its hybrids were followed by a large-scale intrusion of granite, which is biotitic in the terrane rich in aluminous sediments, and hornblendic in the region where the country-rock is preponderatingly hornblendic or pyroxenic. The chilled facies of the granite, on the other hand, is poor in ferromagnesian constituents and resembles the felspathic magma mentioned above. It is, therefore, tentatively suggested that even these granite intrusions are the products of a large-scale assimilation of the country-rock by the initial felspathic magma.

22. A preliminary account of the granite near Myllim, Khasi Hills, Assam.

N. N. CHATTERJEE, Calcutta.

Of the many patches of porphyritic granite in the Khasi Hills, the one occurring near the village Myllim (91° 49′ : 25° 29′) has been described

in the paper. The granite is intrusive in the quartzites of the Shillong series, and xenoliths of quartzite in granite have been obtained from several places. Different varieties of granite ranging from fine-grained aplite to coarse-grained biotite-granite and even to pegmatite have been noticed. Numerous basic segregation patches in the porphyritic variety occur. The structural features of the granite are discussed. The granite is traversed by numerous aplite and pegmatite veins, and their characters have been described in the paper.

Some of the granites contain blue quartz, and in the biotite-granites pleochroic haloes around inclusions in biotite have been noticed. The other microscopic characters of the rocks have been enumerated in the paper.

23. The age and correlation of the hypersthene-dolerite series of Deoghar, Bihar.

S. K. Ray, Calcutta.

In previous communications the Archæan gneisses and associated basic rocks of the Deoghar sub-division of the Santal Parganas (Bihar) were discussed.

Some new areas have since been studied, and the existence of a series of hypersthene-dolerites and gabbros with their metamorphic equivalents as widespread rock-types, not only in Deoghar but also in other parts of Bihar, is now proved.

From several considerations it is concluded that they are probably of a late Dharwar age. However, they are quite distinct in their petrological characters from the hypabyssal representatives of the Dalma trap series and the Newer Dolerites of Singhbhum. Hypersthenic intrusions of such description, if not altogether absent, appear to be very rare in the Archæan rocks of this age.

24. Basic dykes in the Bhima series in the southern parts of the Surapur taluq, Gulberga district, Hyderabad State.

C. Mahadevan, Hyderabad.

A medium grained basic dyke runs from the gneissic inliers (amidst sedimentary formations) north of Mallur (16° 27′ : 76° 7′) cutting through shales and limestones. This dyke is clearly intrusive into the gneisses as well as into the shales and limestones. Xenoliths of gneisses, shales and limestones are seen enclosed by the dyke along its contact zone. Evidence of induration and assimilation of shales and limestones is also noted along the contact plane. Another basic dyke, but finer grained, is seen between Kamnetgi (16° 24′ : 76° 31′) and Srinivaspur (16° 26′ : 76° 33′) cutting through sandstone and shales. The field relations and petrology of the two dykes are described in the paper. These dykes are contrasted with other dolerite dykes of the area belonging to the pre-Purana period, over which the beds are clearly deposited.

25. The Deccan trap of Janjira State, Bombay Presidency.

V. S. Dubey *and* C. W. Chiplonker, Benares.

During a recent survey of Janjira State some very interesting rocks were observed, of which a petrographic and chemical study has been carried out. In general the rocks are different from those occurring further north in the islands of Bombay, Bassein and Salsette. It appears that the chain of acid rocks followed from Cutch up to Bombay dies out more or less completely in this area. A fine-grained compact basalt is

the common rock type ; but more basic varieties, as also some coarse-grained rock types with phenocrysts of felspars and ferro-magnesian minerals, large enough to be seen with the naked eye, are not uncommon. Vesicular, basic, ashy rocks with plenty of zeolitic minerals and secondary silica are also met with. An acid rock of pumiceous type was picked up at only one locality two miles north of Shriwardhan ; it appears to be a very rare rock type, and its mode of occurrence is not clearly known. As a general sequence in the field, the trap is succeeded by laterite, bauxite coming at the top as a very common feature.

26. The heavy mineral residues of the Dome-Gneisses of Kodarma, Bihar.

HAMZABHAI *and* S. K. ROY, Dhanbad.

The heavy mineral residues of the Dome-Gneisses of Kodarma have been separated by bromoform and studied under the microscope. For noting frequencies the method of the Geological department of the Burmah Oil Company has been followed. The division of the Dome-Gneisses according to their colour into three distinct types, namely pink gneiss, light coloured gneiss, and grey epidote-gneiss, has been further supported by the nature of their heavy minerals. For example the light coloured gneiss and the epidote-gneiss are richer in heavy minerals than the pink gneiss. The percentage varies from 0·20 to 2·2% in the pink gneiss, 0·31 to 1·07% in the light coloured gneiss, and 53·904% in the epidote-gneiss.

Zircon is present in almost all the samples. Hornblende, biotite and garnet are the important heavy minerals in the light and pink coloured gneisses, while epidote is the main constituent in the epidote-gneiss and forms more than 90% of the residue.

Sphene and fluorite are common heavy minerals in some slides. Monazite is found only in one sample of the light coloured gneiss, and comprises about 20% of the residue.

27. On the occurrence of a peculiar pulverulent deposit near Hiriyur, Mysore State.

S. LAKSHMANA RAO, Bangalore.

The deposit is found on all the prominent landmarks on the banks of the river Vedavati near Hiriyur (76° 37′ : 13° 57′) in the Chitaldrug district. It is unstratified and varies in thickness from half a foot to three feet. The material is fine grained, not quite soft to the touch, buff to dirty white in colour, and falls to powder on gentle pressure. Under the microscope it is found to be made up mostly of an isotropic substance, having the peculiar curved sides and sharp angles so very characteristic of finely divided pumicious glasses, a few grains of zoisite and some patches of chlorite. A sample on analysis gave moisture 1·01%, loss on ignition 5·60%, SiO_2 72%, Fe_2O_3 2·56%, Al_2O_3 12·04%, CaO 0·80%, MgO 0·39%, and alkalies 6·61%.

No traces of organic remains have been found, and the deposit is concluded to be in the main a devitrified volcanic ash that has been deposited on the flood plains.

28. The occurrence of a steam cavity in a basaltic hill at Sewri, Bombay.

A. S. KALAPESI *and* R. N. SUKHESWALA, Bombay.

A steam cavity of dimensions $50 \times 15 \times 6\frac{1}{2}$ feet was discovered during blasting operations in a basaltic hill at Sewri (19° 0′ : 72° 53′), a small village in the north-east corner of the Island of Bombay.

This hill is situated to the east of the Sewri Cemetery and runs almost north-south for a distance of about 200 feet and is about 75 feet high. The whole hill range is a basaltic lava flow.

The entrance to the cavity was in the form of two holes (about 3 feet in diameter), the inside of which was coated with zeolites and some calcite. Two quite distinct varieties of zeolites were noticed :—green, hard Prehnite developed on the roof and the sides of the cavity, and a white, crumbling variety of Laumontite, mainly encrusting the floor ; also Laumontite is found to have developed in small, stray patches on the roof as well as on the sides of the cavity.

Petrology (Metamorphic)

29. The Archæan complex of Hazaribagh, Bihar.

H. N. Ganguli, Calcutta.

Immediately to the east of Hazaribagh town, granitic rocks have invaded a pre-existing series of sills and intrusions of hypersthenic dolerites producing amphibolites and garnet-pyroxene-epidote-plagioclase rocks and hybrid gneisses. These have in turn been invaded by later pegmatites and aplites. The processes of metamorphism of the dolerites and the formation of hybrid gneisses have been discussed in detail. The garnetiferous rocks have been shown to be the result of additional metamorphism of the pre-existing basic rocks during the granitic intrusion. The granitic rocks appear to be of the same (post-Dharwar) age as the Chota-Nagpur granite-gneisses, and the dolerites to be equivalent to the Dalma Traps.

30. Stages of secondary metamorphism of the Dharwar schists in parts of the Yadgiri taluq, Gulberga district, Hyderabad State.

Syed Kasim, Hyderabad.

In the central and eastern parts of Yadgiri taluq, amidst the Peninsular complex, are seen minor patches of hornblende-schist. These schist patches show progressive alteration through mere recrystallization of the hornblende of the schists to saussuritization of felspars and biotitization of the hornblende. Crushing and strain phenomena in quartz accompanied by zoning are generally observed in the process. The paper traces the progressive stages of the secondary metamorphism undergone by the hornblende-schists, and discusses the probable agencies responsible for the structural and mineral alteration.

Economic Geology

31. Gold in the North-West Frontier Province.

A. L. Coulson, Calcutta.

After giving details of previous records of gold in the North-West Frontier Province, the author deals at length with recent gold-washing experiments conducted on the initiative of Lieut-Colonel E. W. C. Noel, Director of Agriculture in the Province, on the sands and gravels of the Indus river in the Peshawar district and of the Chitral (Mastuj and Yarkhun) river in Chitral.

With regard to the Indus river, the author discusses the gold being brought down annually each summer flood season, and notes the methods adopted by the indigenous gold-washer to recover this. He also states that it would be of interest to sample systematically in certain suggested

localities the gravels across the present bed of the Indus, noting their nature, extent and gold content, if any, and plotting this last against the surface velocity of the river at each of the places of sampling.

With reference to the gold in the accumulated gravels of the Indus, it is considered that sluicing and not dredging is the best method for its recovery, and details are given of a sluice designed for the use of the indigenous gold-worker by Dr. J. A. Dunn.

Colonel Noel's experiments proved the assertion that the auriferous gravels of the dry tributaries of the Indus below Attock are richer than those of the river itself. The source of the gold of these gravels is possibly slightly auriferous quartz-reefs in the Attock slates of the region.

Only the annually deposited gold is being recovered in Chitral. It is possible that the gold that is responsible for the gold in the Reshun Gol, the Golen river, and the Rahman Gol, and in the Yarkhun, Mastuj or Chitral river lower down, occurs in a finely disseminated state in the igneous rocks forming the Phargam mountain complex ; and it is extremely unlikely that one will be able to trace its source, or that the Chitral gold will ever be worked except where Nature has concentrated it in the river gravels.

32. Kyanite deposits near the Rakha mines, Bihar.

S. K. Roy, Dhanbad.

The kyanite deposits near the Rakha mines, Singhbhum district, Bihar, were mentioned by Dr. J. A. Dunn (*Mem. Geol. Surv. Ind.*, LII, 1929), but so far no detailed mapping of the deposits and chemical and mineralogical investigations of the various grades of kyanite of this place have been undertaken. In this paper, which includes a detailed 4″= 1 mile scale geological map of the deposits, the author deals with the geology of the deposits and the chemical and mineralogical aspects of the various grades of kyanite. The kyanite seems to show certain effects of pneumatolysis. At many places it is found in association with tourmaline, and at one place a reef of kyanite has been found to be intruded by a 3-inch vein of rutile containing well developed crystals of the minerals up to about 15mm. in length and about 3 mm. in diameter. This rutile deposit seems to be of economic importance.

In all 14 different specimens of kyanite of this area have been subjected to detailed chemical analysis. On comparing these analyses with the microscopic characters of the mineral, many interesting relations between the chemical composition of the various grades of kyanite and their mineral composition have been observed.

33. The possibility of the utilization of the magnetite sands on the Ratnagiri coast.

M. S. Patel, Bombay.

Continuing previous work, the magnetic sands were further treated in a magnetic separator. By varying the current intensity in the coils, and also by adjusting the distance of the magnetic discs from the particles, it has been found that a product suitable for the market can be obtained from the magnetite sands on the Ratnagiri coast. The market demands a product containing more than 44% TiO_2 and less than 2 to 3% silica. A plan has been worked out by which a product containing about 46% TiO_2 and about 1·0% silica can be obtained from the sands which generally contain from 12 to 27% TiO_2.

The sand is first passed through a 100 mesh sieve and then passed through a magnetic separator, first using very low intensity current in

the coils. This separates most of the magnetite. The material that has not been picked up by magnetic discs is passed through the magnetic separator again, raising the intensity of the current in the coils. By careful adjustment of the current intensity and the distance between the magnetic discs and the particles, a product containing 45 to 47% TiO_2 is obtained.

The sand when heated at a higher temperature increases in weight. This is due to the formation of higher oxides of iron other than those present in the sand. Experiments on the magnetic roasting of the sand, followed by passage through the magnetic separator, in order to obtain a product having very high TiO_2 content, are in progress.

34. The possibility of the utilization of low grade chrome ore in the Ratnagiri district and Savantwadi State.

M. S. PATEL, Bombay.

In 1910 a short note appeared about the existence of low grade chrome ore in the Ratnagiri district. It seems no notice was taken of that note until 1929, when a firm took out a prospecting license for the deposit. Another deposit within about a mile from this deposit has subsequently been located in Savantwadi State. The ore consists of small grains of chromite cemented together in silicious material, and contains on the average about 35% Cr_2O_3.

The ore as such is not marketable. A method has been worked out for the concentration of the ore yielding a product containing about 50% Cr_2O_3, 25% iron oxide and less than 2% silica. Due to the higher iron oxide content of the concentrate, it is difficult to find a market for it. Moreover, most of the demand for chrome ore is for lump, and very little for concentrate. Experiments for decreasing the iron content of the concentrate are in progress. If the iron oxide content of the concentrate can be brought down to the normal figure of 14 to 15%, it is possible that by briquetting the concentrate the deposits can be commercially exploited.

35. The relationship of the auriferous quartz veins with some acidic members associated with the Dharwar formation in parts of Surapur taluq, Gulberga district, Hyderabad State.

S. K. MUKHERJEE, Hyderabad.

In the course of the geological survey of parts of the Surapur taluq. a conspicuous band of Dharwars, about 15 miles long and 4 miles wide, was mapped in association with a series of acidic members, which occur marginally to the hornblende-schist band. A number of old gold-workings were noted along the marginal zone, specially to the west and east of this main basic band.

The auriferous nature of the acidic members, and hence their relationship with the associated basic Dharwar schists, was discussed by the writer in connection with the Dharwars of the Raichur Do-ab before the Bombay session of the Indian Science Congress in 1934.

In this paper the writer proposes to amplify his remarks regarding this relationship in the light of additional field data obtained from the Surapur taluq. A correlation of these acidic members has been suggested with the 'Champion series' of the Mysore geologists.

Photographs, maps and micro-sections illustrate the paper.

36. A note on the mineralization of some pink and white mottled quartzites associated with Dharwar rocks in parts of Raichur and Surapur, Hyderabad State.

S. K. Mukherjee, Hyderabad.

At Chincholli and Machnur in the Raichur Do-ab, as well as at Tintinne and Nagnur in the Surapur taluq, a series of pink and white quartzites occur closely associated with later quartz-veins and diorite dykes impregnated with cuprite, chalcopyrite, malachite and iron pyrites. Old workings strewn with slag giving traces of copper and iron, left by the ancient smelters, have been noted in the same localities.

The paper discusses the relation of these mineralized quartzites with the auriferous quartz-veins of the Dharwar formation in this area, and suggests that the non-auriferous mineralization as represented by the advent of copper and iron ores in the quartz-veins marks a subsequent activity secondary to the auriferous activity as evidenced by the gold-bearing quartz-veins of the area.

37. A note on 'steatite' at Sarkana, Bijawar, Central India.

T. Das Gupta, Calcutta.

The 'steatite' deposit at Gorera Pahar, Sarkana, in Bijawar State, C.I., is described in this paper. The deposit is really composed of the mineral pyrophyllite, which forms a large proportion of the 'steatite' or 'talc' of commerce (Mineral Industry of the British Empire, 1913–1919, Imperial Institute, London). The mineral is translucent, subcrystalline or massive in nature, and rather harder than talc (H.$=$1·5). Other physical properties of the mineral and its chemical analysis are recorded. The extent of the deposit and the uses to which the mineral could be put are discussed. The probable available quantity is estimated at about 150,000 tons.

The deposit is formed by a dolerite dyke cutting across a reef of vein-quartz. Transitions are noticed between the original rocks, through quartz-dolerite and steatite-dolerite to pure steatite-rock. The latter sometimes contains inclusions of long prismatic crystals of diopside.

38. The occurrence of calcite near Sankaridrug, Salem district.

V. S. Dubey *and* C. W. Chiplonker, Benares.

Recently in a visit to the area around Sankaridrug in the Salem district, very rich deposits of calcite were located. The mineral occurs in four or five vein-like masses each up to about 150 feet wide; they are observed running parallel to each other in a direction approximately E.-W. and can be followed for about five miles. They occur in a granitoid country rock in the immediate neighbourhood of Sankaridrug.

The deposit contains up to 90% of carbonate of lime, alumina, silica and minute quantities of magnesia making up the rest of the mass. This mineral extends down to a good depth. The authors discuss in the paper the origin of these calcite deposits and their economic possibilities, such as the production of calcium carbide and bleaching powder with the help of cheap power available from the Mettur power station.

39. On the origin and composition of calcareous earth deposits occurring along the junction of the limestones of the Bhima series and the Peninsular Gneisses between Chennur and Hebal Buzurg, Surapur taluq, Gulberga district, Hyderabad State.

C. Mahadevan, Hyderabad.

Fringing the sedimentary formations of the Bhima series in the south-western parts of the Surapur taluq (Gulburga district) is seen a

narrow band of pink syenite which runs in broken continuity from south of Bopargi (16° 23′ : 76° 18′) to the south of Wajal (16° 29′ : 76° 32′). Between Wajal and Hebal Buzurg (16° 29′ : 76° 45′) the place of the syenitic band is taken by deposits of milk-white, fine calcareous powder, about a mile in length, with an average width of about 100 yards. A type sample of the calcareous deposits gives the following composition :—

Insoluble in acid	9·2%
CO_2	38·5%
CaO	51·5%
MgO	0·3%

It is suggested that the original syenites that fringed the sedimentary beds between Wajal and Hebal Buzurg were firstly kaolinized, and were later replaced and enriched by carbonates from circulating solutions. On account of the white colour and the high percentage of calcium carbonate of these deposits, with magnesium in negligible quantity, they constitute an excellent raw material for a high grade lime industry.

40. On the limestones and shales of the Bhima series in the south-western parts of the Surapur taluq, Gulberga district, Hyderabad State.

C. Mahadevan, Hyderabad.

The Bhima series in the south-western parts of the Surapur taluq total in thickness about 300 feet, and consist of a lower division of conglomerates, sandstones and shales, and an upper division of limestones. The shales are green to purple coloured, and grade through calcareous shales to pure limestones. Several colours in the limestones beds are recognized, such as red, cream, buff and black. Some of the limestone beds show on the surface deep pits like molluscan borings, due to weathering. Others which are more siliceous are free from these pits, and include amidst them massive lenses of cherts of various pleasing colours and patterns. The paper describes the composition of some type shales and limestones, and discusses their economic value.

41. The building stones of the Raichur district, Hyderabad State.

C. Mahadevan, L. S. Krishna Murthy, *and* Syed Kazim, Hyderabad.

The superiority of the granitoid gneisses of the Raichur district, even to the famous Aberdeen granites, as building stones has long been recognized. The gneissic slabs used in the hill forts of Raichur, Mudgal, etc., exhibit *par excellence* their grain, tensile strength, and the sizes in which they can be split. The red syenites and pink porphyries, with pistacite veinlets cutting through them, and the granodiorites afford attractive material for decorative purposes. The paper describes the field characters, petrology and physical properties of the building stones of the Raichur Do-ab.

42. A note on the investigation of brine by means of a series of test bore holes along the Sarjapur *nala*, Raichur district, Hyderabad State.

L. S. Krishna Murthy, Hyderabad.

Large quantities of weak brine and saline earth have long been noticed in parts of the Raichur Do-ab and the Gulberga district, Hyderabad State. A number of salt works still exist employing crude methods of

salt manufacture. A salt and brine survey was made, and experiments on improved and quicker methods of evaporation of brine conducted with a view to reviving this struggling cottage industry on a sound economic basis.

In connection with the above scheme, a series of test bore holes were put down along the bank of the Sarjapur *nala*, with a view to ascertaining the nature and quality of the brine available for the supply of a sustained cottage industry. Periodic observations of the bore holes were kept up for a period of over two years.

The paper discusses the data obtained regarding the nature, quality and distribution of the brine available in the test area.

Maps, charts and graphs illustrate the paper.

43. Ancient glass-making in Mahabubnagar district, Hyderabad State, with special reference to the raw materials used.

L. S. Krishna Murthy, Hyderabad.

In Gazulpet (16° 39′ : 77° 59′), Gazulu Manikonda (16° 43′ : 77° 53½′) and Ramchandrapur (16° 42′ : 77° 54′), Mahabubnagar district, Hyderabad State, many old glass smelting furnaces are found in ruins, testifying to the once flourishing glass-making industry in these parts. Even now, only rarely, a furnace or two may be seen active in the hands of some skilful workman who still clings to his home industry handed down from generations past. The glass was used in making glass bangles, and this cottage industry practically monopolized the supply of bangles in the State. The influx of cheap and attractive imported material has been a great set-back to this cottage industry, which is now fast dying.

The paper describes the plant, its construction, the raw materials used, and the methods adopted in obtaining soda ash from the saline and alkaline efflorescent earth abundantly found in the area. The author suggests methods that may be adopted to revive this dying cottage industry.

Specimens, photographs and sketches illustrate the paper.

44. Saline deposits in Hyderabad Dominions.

T. V. M. Rao, Hyderabad.

Various views have been offered for the salinity in the water supply of parts of Raichur and Gulberga districts and the one favoured by the local Geological Survey Department is that it is derived from the acid representatives associated with the Pink Gneisses forming part of the Peninsular Complex.

During an economical survey recently carried out in these districts it was realized that the views expressed were without full consideration of the palæogeographic conditions that prevailed in this area, which formed part of the vast Gondwana Land, at the time of formation of these salts. What seems more probable is that chemical deposition of saline material took place, possibly due to excessive evaporation, in a shallow, landlocked lake, which later became deeper giving rise to the Bhima Series of shales and limestones. These beds of later formation have overlapped and sealed up the underlying saline deposits, except in isolated places due probably to minor faulting of the superincumbent beds. From these faulted areas small amounts are brought to the surface by meteoric waters finding their way to the different water sources causing them all to be more or less saline.

Water Supply

45. The problem of Karachi's water supply.

M. B. PITHAWALLA, Karachi.

Water supply is the most hotly discussed problem in Karachi to-day. It is feared that by 1961 the population will be double the present one of 300,000, and will require a daily supply of 30,000,000 gallons, of which the present Dumlotte system of 7 wells, 26 miles away, yields about one third only.

Various suggestions have been made for its improvement:

1. Drawing upon the alluvial flow by putting down more wells in the Malir valley.
2. Boring tube-wells into the alluvium.
3. Making an impervious diaphragm across the Dumlotte gorge.
4. Constructing a dam or dams across the Khadeji or the Hab.
5. The Indus scheme of cutting a 100-mile canal from Kotri.

All these rather doubtful and expensive schemes are criticized in the paper, and the whole problem is solved *geologically*, backed with a proposal for artesian borings in the river basins. The geological, topographical and surface and underground drainage features, consequent upon Sind's peculiar rainfall, are sufficiently discussed to show the necessity for an artesian supply, supplementary to the Dumlotte one. But for the single exception of the Drigh road borehole of 1924, and the shallow borings in wells 3 and 6, sufficient data have not been obtained to disprove the possibilities of a plentiful and potable supply tapped up to 1000′, and in Nari sandstones. An expenditure of a lakh of rupees on trial borings at this critical moment is justifiable, and may bear good fruit.

46. Sub-soil water level and crop security in the United Provinces.

B. MUKHERJEE, Lucknow.

The extension of agriculture and the limited potentialities of surface irrigation have both led to greater utilization of the sub-soil water in the United Provinces for purposes of irrigation. Ever since the Ganges grid electricity scheme was completed the whole sub-soil reservoir has been commercially exploited by hydro-electric energy. This has raised grave apprehensions as to the stability of the sub-soil supply on account of the enormous volume of water that is being abstracted. The question is very important for the ultimate security of crop irrigation on the one hand, and of the taxpayers' money on the other. Three expert enquiries have recently been carried out on this question. In this paper, the views expressed by these enquiries are summarized and discussed, and it is agreed that their conclusion that, on the data available, there is no immediate risk of a sub-soil vacuum, is a correct one.

47. The economics of tube-well irrigation in the United Provinces.

B. MUKHERJEE, Lucknow.

Tube-well irrigation has been rapidly developed in the United Provinces in recent years, firstly as a substitute for canal irrigation, and secondly due to the completion of the hydro-electric grid works on the Ganges. The paper discusses the great advantages of electric tube-wells in the scheme of irrigation. The old motor engines were too cumbrous and too costly to be economically used. The tube-wells have reduced the cost of water to the cultivator, and their capital cost per cusec. is only

one-seventh of the canal cusec. Even allowing for the cost of power which the tube-wells would need as against the canals which supply the water by gravity flow, the tube-well cusec. is 30 per cent. cheaper than the canal cusec. The tube-wells can be located just where they are wanted, as against the canals which have to be carried over long distances of arid and unculturable areas where they can be of no use. The lost opportunities thus make for a higher incidence of canal water rates.

The volumetric supply in tube-wells is a great advantage, which makes for economy in the use of water. The paper discusses its advantages over canal water on the ground of volumetric supply, and points out the evils of the uneconomic use of water. The recent conversion scheme in the United Provinces, by which canal water released by tube-wells is shifted to areas outside the canal zone to irrigate arid tracts, is discussed in detail, and it is pointed out how the scheme is substantially unfair to the donor areas, which suffer from lower water-levels, less water, and greater cost of cultivation, in order that the distant donees may benefit. It would be dangerous to upset stabilized agricultural conditions by any rapid extension of the conversion scheme.

48. Artesian springs at Wajal, Chennur and Marlbavi, Gulberga district, Hyderabad State.

C. Mahadevan, Hyderabad.

At Wajal (16″ 29′ : 76″ 33′) in the Surapur taluq, Gulberga district, are seen some perennial springs that spout to a height of about a foot to two feet, and replenish the *nala* lying adjacent to the springs. Similar springs are seen near Chennur (16° 29′ : 76° 33½′) and Marlbavi (16° 27′ : 76° 27′).

At all these places highly jointed limestones constitute the upper beds, and these are underlain by shales. The springs are slightly warm. The structural and physiographic peculiarities accounting for the occurrence of these springs are described in the paper.

Engineering Geology

49. The outcrops of Inter-trappean beds and their effect on road construction in the island of Bombay.

G. G. Narke, Poona.

In this paper the author has described the subsidence on one of the hill roads in the island of Bombay caused by the presence of Inter-trappean beds of shales and clays under the hard grey trap rock, and has suggested the remedy of draining off the locality at the junction of the two formations at a lower level.

Geography

50. Climatic conditions in the lower Indus basin (Sind).

M. B. Pithawalla, Karachi.

The paper deals with the climatic conditions of the lower Indus basin (Sind) and is based on a pioneer study of over 30 years' data, collected from records of the Indian Meteorological Department, the Gazetteers, etc. In no other region in India are climate conditions more unique, irregular and unstable. The thermal equator passes through Sind, which thus becomes the driest and the hottest of all Indian provinces. Aridity is its common feature, e.g. Jacobabad has a mean maximum temperature of 113°F, and a mean humidity of 41. The climatic conditions are accentuated by its physical features, the Thar desert in the east, the sea in

the south, and the Hala-Suleiman mountains, with their peculiar re-entrant angle, in the north and the west.

The diurnal and monthly range of temperature is great, e.g. over 45°F in a single day at Jacobabad. The weather is drier and more bearable, though hotter, in the south than in the north. The skies are generally clear and frost is not uncommon. While in Upper Sind it is calm for nearly half the year, nearer the coast the wind velocity is about 15 miles per hour in the monsoon season. Dust storms and squally weather are usual in the beginning of both the seasons. The prevailing winds are S.S.W., S.E., and W. in summer, and N.N.E. and N.W. in winter.

Rainfall in Sind is not only precarious and scanty, but also the most variable in India, with only about eight rainy days in the whole year. Its orography is mainly responsible for this. The greatest peculiarity about the rainfall graphs is that after periodic gaps of about six or seven years of scarcity, there are peaks of good or at times heavy rainfall, though it is hard to determine a cyclical period.

It is a question whether there has been any climatic change in Sind, as the history of the province shows that there was greater rainfall in the past and that inland forests existed. It is equally difficult to determine whether Sind will see wetter days with perennial irrigation, afforestation and continuous evaporation now that the Sukkur barrage has been built.

51. The industrial crops of ' Kerala ', Madras Presidency.

G. Kuriyan, Madras.

Kerala is the country bounded by the Arabian Sea on the south and west, by the Western Ghats on the east, and by the district of south Kanara on the north.

The density of population is much higher than in other parts of India, being 660·9 per square mile. It is able to support such a high density because of the natural advantages, especially climate, which the region possesses (complete absence of drought and a well regulated heavy rainfall ranging from more than 60″ to about 150″ or even more in parts).

There are four important industrial crops grown within this region; namely coconut, tea, rubber and coffee.

Crop.	Acreage.	Number of persons employed.
Coconut	936,124	190,345
Tea	87,705	72,393
Rubber	85,000 (approximate).	11,608
Coffee	9,842	3,349

Coconut. Climatically the tree thrives best where it is most constantly warm, though moisture is more important than temperature. Conditions should be such as to permit the most active possible transpiration. About 70″ of rainfall is the average required. The essential requirement is that the roots must have plenty of water, and it is moving water in the ground which is primarily responsible for the high development of the trees on shores.

Tea wants a warm sub-tropical climate rendered more or less continuously damp by an evenly distributed rainfall of not less than 60″, with a daily range of temperature between 75° to 85°F. In Kerala the region lying above 2500′ elevation satisfies these climatic conditions.

Rubber requires a rainfall of 80″ or more, with a high temperature throughout the year (more than 80°F), and an absence of wind. It is found up to an elevation of 1000′ on the slopes of the Western Ghats. Higher up the region is too windy for rubber, and tea takes the place of rubber.

Coffee wants an optimum mean annual temperature of 68°F to 70°F, and it must be protected from heavy winds. It has a total area

of 9,842 acres and is found mostly in the district of Malabar and Cochin, due perhaps to the proximity of these regions to the other coffee growing regions of the Nilgiris.

52. The human geography of the post-Tertiary alluvial and sandy belt of the Madras coast.

N. SUBRAHMANYAM, Madras.

The post-Tertiary belt of the Madras coast, consisting of marine alluvium and blown sand, forms an interesting study in land utilization and awaits systematic development. The region is broken up by a few lagoons and backwaters, and the low-lying parts become swampy in the rains. The soil is very poor, being for the most part sandy and saline; and the natural vegetation is sparse, though adapted to the prevalent conditions.

It is interesting to find this unpromising region being developed in a way suited to its peculiar conditions. These developments are—the manufacture of salt at several places; the growth of hundreds of hamlets of fishermen who venture out into the sea in their frail catamarans; the collection of sea-shells from the marine beds of some of the islands for making building material; the planting of coconut, casuarina and cashew-nut trees which are all specially adapted to the soil; and the digging of a canal along the belt, enabling the transport of the products of these industries to the metropolis.

For the better development of this region, the canal which is in a neglected condition has to be improved, the underground water resources to be tapped, and feeder roads have to be constructed to the canal.

SECTION OF BOTANY

President:—H. G. Champion, M.A., F.N.I.

Presidential Address

THE NEED FOR SCIENTIFIC STUDY OF INDIA'S CLIMAX VEGETATION.

It is estimated that out of her 1,826,924 sq. ms. of land surface, 465,288 sq. ms. or some 25·5% is still under forest growth of one sort or another. The proportion varies greatly in the different provinces, the maximum proportion being found in Coorg (74%) and Burma (60%), and the least in the Punjab (6·7%) and Bombay (11·9%). Disregarding the present political boundaries, there are large tracts such as the Gangetic plain and Berar where practically no forest is found, and others such as Upper Assam and the W. Ghats where there are great blocks of forest but little cut up by human settlements. The forestless tracts are however by no means devoid of trees, for scattered mango, neem, figs, tamarinds, and so on are almost everywhere to be seen, silent evidence that the climate and soil are fully capable of supporting tree growth, even if we had not definite historical evidence that most of the land now under cultivation once carried dense forest—as also a good deal of land which though formerly cultivated is no longer fit for crops.

Closer study and comparison with other countries brings out the fact that over practically the whole of India the climax vegetation is forest. There are parts of course, particularly in the Punjab, Sind, and Baluchistan, which are too arid for closed forest, and there are relatively small areas in the high Himalayas which are too high and cold for it, but apart from these extremes, and including thorn scrub as a form of forest, we are left with only a small proportion of grassland, mainly in riverain tracts and on hill tops, about which there can be any doubt. India does not provide the conditions appropriate for the development of climax grassland comparable with the Pampas of S. America, or steppes like those of S. Russia. The actual status of our grasslands will be touched on later.

It is thus clear that forest is certainly India's present dominant vegetation type, and probably its nearly universal climax type also. It might therefore be expected that the tree and its aggregate form, the forest, would provide the material for at least a significant proportion of the botanical studies undertaken, always remembering the still greater importance of

agricultural food crops to mankind. It is one of the chief objects of this address to bring to the notice of working botanists how far this is from being the case.

There is another direction in which the value and importance of tree growth to humanity is only beginning to be adequately realised. It may not be a purely botanical matter, but we cannot have plants without soil, and the forest is the great builder and conserver of the soil. That the finest soil, particularly in tropical climates, is to be found where forest has just been cleared has been known further back than our written records, as also the fact that it rapidly loses its fertility on exposure and repeated cropping. That the fertile upper soil is largely destroyed or washed away when the forest cover is destroyed is not generally realised till the pressure on the land becomes so severe that there is no longer enough new land available to which to move when the production of existing fields falls below what is considered worth the labour of cultivation. This is of course the position over all the more densely populated parts of the country. The further stage where sand, gravel, and stones from the subsoil in the upper parts of water catchments are also set in motion by the monsoon downpours typical of the country, leaving the ground denuded down to barren bed rock, and burying good soils further down the natural drainage under almost equally barren and unculturable deposits—is fortunately localised, but has in the last few decades become a matter of first rank economic importance in the Punjab. The loss of soil following on destruction of the natural forest cover and inadequate cultural methods is unbelievably general along the whole length of the great Himalayan Range, and is very apparent on the hill ranges of Southern India. The same processes are in play on the more level ground of our plains, valleys, and plateaux, but are slower, less spectacular, and fortunately more easily countered, but many a field lies abandoned because the fertile forest soil built up by the original forest is no longer there.

This aspect of trees and forest is of course of special interest to the botanical ecologist, who is concerned with the relations between the vegetation and the habitat, with the origins, changes, and future of existing vegetational types. This subject, too, will be discussed more fully later on.

It is proposed here to make a brief survey of what we have learnt so far about the life history—in the widest sense of the term—of our trees and forests, reviewing in turn the main branches of botanical science. In the course of this survey it will become apparent that from a variety of causes, disappointingly little has been done or is being done, that our present ignorance in India is deplorable, and that instead of leading the world in contributions to scientific knowledge in a field for which we are exceptionally favourably situated,

viz., the study of that supreme production of Nature, the tropical evergreen forest, we tend to be content to borrow information and methods of research from northern temperate countries where species, formations and conditions are so very different from our own that the difference is one not merely of degree, but actually of kind. If I succeed in deflecting even a small number of workers from continuing mere duplication of western studies, including what may be termed routine morphological, anatomical, and cytological investigations, compilation of local lists with little attention to relationships, and so on, I shall have achieved my present purpose.

1. Physiology of trees and tree crops.

Water relations.

We have information direct and indirect that the water supply in most of the country during the monsoon period is sufficient to meet all requirements and is in fact often in excess. It is a common observation that there is a marked check in growth in many trees during the later part of the monsoon particularly where the rainfall is heavy. It has been suggested that this may be due to lessened assimilation due to cloudy skies, but the balance of opinion favours the view that it is to be connected rather with the more or less saturated condition of the soil implying poor aeration and stagnation of root activities. A few studies of water absorption from the soil by trees have been published, e.g., interesting studies on some of our mangrove species, but practically nothing has been done on the subject for the normal condition of closed forest growth on typical soils. A good deal of work has been done on the conduction of water up to the foliage of trees because the problem only finds full expression in trees where a height of 200 ft. or more has to be attained. Obviously, however, much work remains to be done to decide between the conflicting theories now in the field, and to determine the conditions under which and the extent to which each may be true. The osmotic forces available in the leaves have been shown to be about 20 atmospheres in fairly typical trees such as *Azedirachta indica* and *Grevillea* and up to 40 for the xerophytic *Tamarix* and even 100 for some mangroves ; in the other direction, *Rhododendron grande* growing in wet temperate forest showed only 6 atmospheres.

Transpiration also has been studied to some extent in so far as experiments have been made with mango, *Eugenia Jambolana* and a few other tree species usually under laboratory conditions well outside the forest. These experiments have their value of course, but they only touch the veriest fringe of the problem. The determination of transpiration rates of twigs of trees under set conditions should only be the first step towards the determina-

tion of the transpiration data for whole forests for comparison with the data for other types of soil cover and their study in relation to the whole water economy of the tract of country under consideration. Despite the very great importance of this problem to India, nothing whatever has been done so far except a minor investigation carried out in the irrigated plantations of the Punjab to determine the relative effect of a cover of grass alone, of grass with trees, and of trees alone on the moisture of the soil when the same irrigations were given—the immediate object being to see whether the cost of uprooting the grass would be justified by a resultant economy of water. Admittedly, in the West also, knowledge in this field is backward, but it is attracting attention as one facet of the great problem of counter-erosion and water economy which has pushed itself into the lime light in the last few years. At the moment, India has to depend on very imperfect data from western countries collected under fundamentally different conditions, data which it is positively dangerous to apply without verification. In this connection, mention should be made of the figures recently published indicating that transpiration rates increase up to a certain value with increasing temperature and falling humidity and then become more or less stationary. If this is generally true, there may not be so great a difference between the water consumption of forest crops here in the dry or moist tropics, and temperate Europe and America, but the matter requires careful verification.

In these matters, transpiration is of course only one of a number of factors involved, but direct determinations of water losses due to it are most desirable since evaporation from the soil surface, and downward seepage of rainfall are equally difficult or more so to determine. At the moment, we are not in a position to say with any certainty whether under the conditions prevailing in a given spot in India, the afforestation of a bare catchment area on which a city water supply or an important irrigation or hydro-electric scheme depends will increase or decrease the proportion of the rainfall which will be lost by transpiration plus evaporation—there are of course other factors, notably erosion and silting effects, that may render the protective action of the forest cover much more important than a somewhat increased evaporation loss. It may be mentioned that under European conditions, it is estimated that a temperate forest appears to transpire the equivalent of about 3″ to 11″ of rainfall annually.

Assimilation.

Equally profound is our ignorance of the assimilation activities of trees and forests.

The forester can supply certain figures which render it possible to compare the relative efficiency of forest and agricultural crops in utilising the incident light for assimilation,

but no one seems to have collected the data and submitted them to any sort of critical study. We harvest the tree crop very largely in the form of ligno-cellulose as contrasted with the sugar, starch, and protein yields harvested in agricultural crops, and at present the value of cellulose lies in its uses as a raw material for industry, not as a food stuff. However, even apart from any views as to how soon it may be practicable and even customary to depolymerise cellulose into a digestible saccharide, it should be evident that we have here a problem to which pure science could well devote more attention. Once again, we would like to have data bringing out the relative effects of the different temperature, light and moisture conditions characterising temperate and tropical climates. In the same connection, it is of course well known that a tree crop makes far less demand on the soil than any other type of crop. This is natural in view of the fact that food and fodder crops derive a large proportion of their value to us from the mineral substances and the proteins they contain, but it must not be overlooked that the forest crop works with far less wastage of material both mineral and nitrogenous so that it can grow on sites useless for food crops and even on those too poor to carry good grass. And above all, the forest cover far surpasses even the more efficient types of agricultural working in conserving the soil itself and particularly the humus content which in the end is, with solar energy, the source of all productivity.

Assimilative activity depends on the quality and intensity of the incident light. Once more, we have to admit almost complete ignorance of the light conditions prevailing at different levels in our climax vegetational types, namely forests. Recently, one or two forest officers have been taking measurements with some of the electrical photometers which have been put on the market for photographic work, and have obtained some interesting results, but this is a subject which requires to be studied by the trained research worker, not by the professional forester as a small side line among his other multifarious duties.

Respiration.

The combined effects of assimilation and respiration form one of the most interesting problems in biology and geochemistry, the carbon circulation of our world, and every scrap of additional knowledge is valuable. The forests are beyond doubt the chief agents in increasing the amount of organic carbon available for the use of the animal world including ourselves, and also in keeping the proportion of the end product of oxidation, CO_2 in the atmosphere below injurious proportions. We require knowledge of respiration processes in the above ground portions of our vegetation to determine what proportion of the carbon assimilation going on there is nett gain, and still more do we

require information about the process as it goes on in the soil where there is no assimilation to counteract it, so that local injurious concentrations become possible with far reaching effect on all the complex processes going on in the soil.

Excretions, etc.

The importance of the rubber growing industry has resulted in considerable work being done on the production and secretion of latex in the American *Hevea*, concerning which I am not competent to speak, but our forest trees are the chief sources of supply of many valuable gums, dammars, resins, and oils.

I am aware of no physiological studies into the production of these substances, and believe that current methods of collection have no scientific basis whatever or are direct applications of foreign methods not systematically tested for Indian species and conditions. The important resin tapping industry of the subtropical Himalayas provides a very good example, offering a big range of interesting and important problems in pure botany with considerable possibilities of economic value also.

The lac industry provides another valuable field to be shared with the entomologist and the biochemist. What are the processes by which the lac insect elaborates so uniform a product from trees which differ so widely, and what are the reactions of the unwilling host in its own food economy? The sandalwood industry is yet another which still offers a wide field despite the very interesting work of recent years stimulated by the seriousness of the spike disease.

2. Soil problems.

This is not perhaps the place to go into soil problems at any length, and yet it has been impossible to avoid all reference to them in the earlier parts of this discourse. The groups of problems with which the botanist is most immediately concerned are those which deal with the humus and the nitrogen cycles. Once again the forest takes foremost place as the great manufacturer of humus and apparently the most economic user. Our need is for Indian data for rates of humus formation with different types of vegetation, for comparative qualitative studies of humus and humus conservation, and for all we can find out about the nitrogen cycle under our own climatic and soil conditions.

3. Genetics.

The long life cycle of trees places a serious obstacle in the way of the would-be student in the field of tree genetics, and yet that very fact should be an incentive both because difficulties

ought to stimulate the scientific worker, and because the longer it is going to take to obtain the answer to a problem, the more important it becomes to make an early start. One is prepared to admit that the general principles evolved from western studies are more readily acceptable for genetics than for physiological problems, even though the higher temperatures and different seasonal variations may well result in a very different tempo for evolutionary processes. This admission however only leaves us with a realisation of the vast amount to be done in this country even if we only have to work on our flora on the lines thus made apparent. I was faced with an interesting problem of this type when I first came out to this country over 20 years ago, and was fortunate in being able to initiate a study on the inheritance of spiral grain in pine which has in the meantime provided us with the only clear case we have among our thousands of species of forest trees of the inheritance of a character of this kind, actually a serious defect in timber. Even so, the research falls short of much that it might have accomplished because the controlled pollination which would certainly have been effected by the whole time physiological worker was not practical to the forester, at least at that time. We also have co-operative study under way in seven provinces and states, of the characters and heredity of the racial strains of the chief timber tree of the East, viz. teak. At the Forest Research Institute, and at the Lac Research Institute, the physiological races of various lac hosts, and many other connected variations, are being examined, almost any one of which is really a whole time study for the trained research botanist.

Selective breeding.

The large amount of work done on food crops and the great economic value of the results in raising actual and potential agricultural outturns are now universally recognised. It is also known that valuable results have been obtained with other economic crops such as rubber by systematic work on selective breeding and improved methods of rapid propagation of a good stock or strain when isolated.

The importance of forestry in India may appear small in comparison with agriculture, but that does reduce the relative value of similar work on trees to both pure and applied science, and the trees at the moment offer an attractive virgin field. Many trees produce individuals with timber much more ornamental than usual for their species, and apparently from no external cause : what are the reasons for it ? ; is it a heritable character ? ; and can a strain be isolated which will reproduce it in all or a high proportion of its offspring ? Some pine trees yield 50 to even 100% more resin than the average for trees of the same size and age growing under the same conditions ;

on the analogy of *Hevea*, it should be possible to isolate high yielding strains, but the worker is still lacking to try.

Hybridisation.

Hybridisation of forest trees is a new study even in the west, but it apparently has possibilities, and there are reported cases of pronounced hybrid vigour in the first generation. India has co-operated in American work in this field but so far done none herself.

4. Ecology.

Root competition.

We have become aware of recent years of the important part played in plant survival by the unseen competition going on below the surface of the ground. The problem is of course far more difficult to follow in trees than in herbaceous plants and has hardly been touched in this country under natural conditions for which the valuable studies on orchard trees can only provide suggestions. In some ways the reactions between the different types of vegetation are almost more interesting than those between individuals of the same species in the same or different stages of development: these reactions of course underlie the whole problem of plant succession. We have the results of a few small experiments on natural regeneration of deodar, etc., and workers in Java have published some valuable observations on the effect of adjoining vegetation on the development of teak plantations, demonstrating that it is more competition for moisture than for mineral food that is in question. The matter is an important one for us in all the drier parts of the country and offers yet another interesting and useful field for research.

Crown competition.

This subject is one with which the forester is probably better able to deal than most professional botanists, and so it can be left to him.

Succession.

As a result of the understandable desire for results within a reasonable period of time, successional studies have been concentrated in undue degree on the shortlived types of vegetation. Probable successions of forest types have been built up by foresters by deduction from general observation of the present distribution of more or less distinguishable types: the simplest are undoubtedly correct but much more specialised study by experienced workers is needed for the rest. Forest

Departments throughout India have during the last few years been selecting suitable areas of forest of all the chief recognised types with a view to excluding them from all working, and rendering them available for scientific study, especially in the field under discussion. It is however unlikely that a great deal can be done in them without the collaboration of botanical workers in a position to devote a good deal of time to the problems they take up, and facilities would gladly be given.

The ecological status of very many of our forest types is a controversial matter. One of the papers presented to this Congress deals with the status of the sholas and grasslands of the S. Indian Hills which is a problem full of interest from many points of view and this is only one of a hundred similar opportunities. It has become apparent of late that many of our important revenue producing *sal* (*Shorea robusta*) forests are only a preclimax rendered stable by the periodic burning to which they have been subjected in the past; the probable climax is on present values a definitely less valuable type.

This leads us to the nature of the climax vegetation itself. I have claimed at the outset that for by far the greater part of the country, the climax is tree forest, but it is not necessarily the forest we find on it at present as just suggested for some of our *sal* forests. Some parts of the country have been so universally and fundamentally influenced by human habitation that it is now practically impossible to indicate any area which can with confidence be claimed to carry the natural climax vegetation, as is the case for the whole of the Gangetic plain of the U.P., Bihar and Bengal. There is considerable academic interest in the question as to whether the accepted climax forms really can maintain themselves, or whether there is a natural rotation of crops, perhaps of the same vegetative form but of different species. This point arises in many types in which, as for the fir forests of the W. Himalaya, the apparent climax tree forest appears to generate soil conditions in which its own regeneration cannot take place.

Distribution problems.

The tree, being large and long-lived, provides excellent material for studies of actual distribution and its underlying causes which do not seem to me to have been fully utilised. Once again, since trees form the dominant vegetation, it is their distribution which must chiefly have determined the whole biological history of the country in the past.

5. Experimental technique.

It is obvious that the study of trees will frequently call for a different technique from that suitable for smaller plants

which can be brought into the laboratory, or to which ordinary laboratory methods can usually be applied in the field, and this has no doubt had a lot to do with the relative neglect from which trees have suffered. The trouble lies in the great size of the unit and the fact that it is very difficult either to reproduce the conditions under which the average tree is growing, or to control them. It is difficult enough to determine what the conditions are in the crown of a tree perhaps 100 ft. above the ground, or at its roots which, though normally mostly in the upper 10 ft. or so of the soil, may penetrate to a depth of even 100 ft. However, as in all other branches of science, these difficulties exist to be overcome, as some of the work done by members of the Oxford University Exploration Society in tropical evergreen forest has shown.

This increased dimensional scale applies to areas also, so that the small quadrat of ecological and succession studies becomes of very little use. Forest workers have accordingly gone over very largely to long linear transects, and to get true samples, experience shews that they must be very long ones. Again it is usually necessary to work over at least five acres to reproduce the desired conditions as to light intensity and general exposure on the floor of the forest in making studies of regeneration.

The problems of sampling call for special intensive studies under forest conditions. The theory of small samples figures prominently since it is rare that experiments or observations can be replicated enough to provide data capable of analysis on the lines developed for agricultural practice, where a square yard sample will meet most requirements and will itself represent the growth of a large number of individual plants.

SUMMARY.

Very little is yet known about the physiology of the individual tree, and still less of the physiology of tree crops. What little information has been obtained nearly all refers to temperate climates, leaving the tropical forests almost unexplored. Only small beginnings have been made in the study of the tropical forest in relation to the soil, to genetic problems and to ecological problems of competition and succession. The study of trees and crops calls for a special technique both in the collection of data and their analysis. India is in a unique and very favourable position to lead the world in this field, the problems awaiting solution being full of interest to the scientific worker and full of importance on their economic side.

SECTION OF BOTANY

Abstracts

Algæ

1. Fertilisation in *Eudorina*.[1]
M. O. P. IYENGAR, Madras.

2. Charophyte notes from Behar.
B. C. KUNDU, Rajshahi.

3. Distribution of Algal vegetation at Solan (Simla Hills).
P. ANAND, Lahore.

4. On the systematic position of *Echallocystis* Bohlin.
M. O. P. IYENGAR, Madras.

Fungi

5. Variations in the structure of the receptacle in a *Simblum*.
M. O. P. IYENGAR, Madras.

6. *Clathropsis*, a new genus of the Phalloideæ.
M. O. P. IYENGAR, Madras.

7. The presence of encrusted cystidia in the hymenium of *Polyporus zonalis* Berk.
S. R. BOSE, Calcutta.

8. A fringe within the pore-tubes of *Daedalea flavida* Lév.
S. R. BOSE, Calcutta.

9. Dissemination of Wheat Rusts.
K. C. MEHTA, Agra.

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[1] Papers which were not actually presented before the session by the author or his representative are included by title only. In none of these cases was the full paper received. (*Vide* Rule 30 (*e*) of the Association Rules.)

10. Intergeneric hybridization and evidence of heterosis in loose and head smuts of Sorghum.

SYED VAHEEDUDDIN, Hyderabad (Deccan).

In order to determine whether loose smut of sorghum (*Sphacelotheca cruenta*) and the head smut of sorghum (*Sorosporium reilianum*) can hybridize, experiments were made by the writer at University Farm, Saint Paul, Minnesota, U.S.A.

Monosporidial lines were obtained by isolating individual sporidia from the promycelia of germinating chlamydospores. These lines were cultured in potato dextrose broth from 7 to 10 days and hypodermically injected singly and in different paired combinations into sorghum seedlings five-weeks old. None of the single lines caused infection but 11 out of 18 paired combinations produced chlorosis on the leaves in 8 to 12 days. Sori later developed in the inflorescences of the chlorotic plants. arising from individual ovaries like *Sphacelotheca cruenta* and not from the entire inflorescence as is the case with *Sorosporium reilianum*. Different monosporidial combinations of the two genera produced sori varying in size and shape. Some of the sori produced were like those of *Sphacelotheca cruenta* in which the individual ovaries were infected, and some were like those of *Sorosporium reilianum* in which the entire inflorescences were infected. Few of the sori were long like those caused by *Tolyposporium filiferum*, and some were even longer than the *T. filiferum* type, i.e., about 7 cm. in length. The hybrid chlamydospores were echinulate like those of *Sorosporium reilianum* and intermediate in size between those of the two parents. The chlamydospores germinated readily and produced promycelia bearing sporidia or numerous hyphal branches with few or no sporidia.

A degree of heterosis was indicated by the production of long sori and by the fact that the promycelia and sporidia were significantly larger than those of the parents. The mean lengths of 50 promycelia of *Sphacelotheca cruenta*, *Sorosporium reilianum* and the hybrid were $25{\cdot}2\mu$, $27{\cdot}3\mu$ and $79{\cdot}0\mu$ respectively, the difference required for significance between any two means being $3{\cdot}94\mu$. The mean lengths of 100 sporidia of *Sphacelotheca cruenta* were $11{\cdot}3\mu$, of *Sorosporium reilianum* $5{\cdot}6\mu$, and of the hybrid $12{\cdot}7\mu$, the difference required for significance being $0{\cdot}24\mu$.

Monosporidial lines isolated from the hybrid chlamydospores and inoculated singly and in different paired combinations into sorghum seedlings produced sori of the F_1 types. Monosporidial lines alone again caused no infection. Chlamydospores from the F_2 sori germinated with long promycelia, sporidia and hyphal branches like those of the F_1. This proved that the hybrid was fertile and heterothallic. Back crosses of the hybrid with both the parental lines indicated that the hybrid lines were interfertile and could unite with either of the parents and infect the host.

When the nuclei of the promycelia from the germinating chlamydospores of *Sphocelotheca cruenta*, *Sorosporium reilianum* and the hybrid were stained, 4 dark staining bodies in diploid and two in haploid nuclei are observed. These dark staining bodies are possibly the chromosomes. There is thus homology in the chromosomes of *Sphacelotheca cruenta* and *Sorosporium reilianum*, and normal meiosis and segregation for grandparental types in the F2 generation.

Hybrid vigor, as it is found in animals and higher plants, is evident in this intergeneric hybrid. Different smut types obtained in this intergeneric hybrid are interesting from taxonomic point of view.

11. Smuts of the Punjab—I.

C. L. SAWHNEY, Lahore.

12. Study of mycorrhiza of some Conifers from Kashmir.[1]

C. L. MOHAN, Lahore.

Pinus longifolia, Abies spectabilis and *Cedrus deodara* have been studied regarding mycorrhiza.

Specimens were mostly collected during July-August in 1935. Some were fixed for anatomical studies. Roots with mycorrhiza can be distinguished by their profuse branching and tufted appearance. The colour of roots within mycorrhiza also varies from species to species.

In *P. longifolia*, the mycorrhiza is ectotrophic—surrounding the cortex : in *C. deodara* is both ectotrophic and endotrophic ; and in *A. spectabilis*, it is endotrophic.

The fungi from the three species have been isolated and their characteristics in culture studied. No spores have been formed in any of the forms so far but the one in *P. longifolia* formed sclerotia in potato-glucose agar culture. The form from *A. spectabilis* has been saltating freely.

Seedlings of all the above plants have been raised in agar culture, free from mycorrhiza and these are now being grown in sterilised soil. Inoculation experiments of the seedlings while growing in agar culture and under control in soil, are proceeding. No definite results have so far been obtained.

13. A leaf-spot disease of the bean plant (*Phaseolus vulgaris*).

C. L. SAWHNEY, Lahore.

14. Studies in Water-Moulds—Part III.

H. CHAUDHURI *and* A. HAMID, Lahore.

15. Fleshy fungi of Kashmir—I.

A. HAMID.

16. Leaf-spot disease of *Camellia japonica*, due to *Alternaria* sp.

A. R. QURAISHI, Lahore.

17. A new disease of *Anthoceros erectus*.

H. CHAUDHURI *and* A. R. QURAISHI, Lahore.

18. A disease of *Pentatropis cynanchoides*.

A. R. QURAISHI, Lahore.

19. Actinomycetes of the soil in relation to manurial treatment and season.

JAGJIWAN SINGH *and* H. CHAND, Lahore.

20. Fungous flora of the Lahore soils. II.

JAGJIWAN SINGH *and* H. CHAND, Lahore.

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[1] This paper was not formally presented, but the abstract is included as there was some discussion on it.

21. A quantitative study of soil Bacteria of the Punjab.

JAGJIWAN SINGH *and* H. CHAND, Lahore.

22. Sectorial infiltration of pine sleepers.[1]

H. CHAUDHURI, Lahore.

When sleepers for the railways were treated under pressure with a cold solution containing arsenic, potassium bichromate and copper sulphate, it was found that in some case only partial infiltration took place along certain sectors. Sections of small blocks of the wood from the portion showing infiltration and also from outside the sectors have been cut with a wood microtome, stained, and examined under the microscope. The presence of fungal hyphæ in the sectors could be seen, though in many cases, the hyphæ disappear later. The bore-hole of the hyphæ and dissolution of the middle lamella by the fungus help in the passage of the cold preservative under pressure.

It has been possible to isolate the fungus from the untreated sleepers. The Sleeper Control Officer, kindly arranged to have only the halves of a number of sleepers treated and whenever the treated halves showed penetration in sectors, the corresponding portions of the untreated halves were chosen for isolation of the fungus. A detailed description of the fungus and its mode of penetration have been given in this paper.

Bryophytes

23 On the morphology of *Riccardia Levieri* Schffn.

S. K. PANDE, Lucknow.

(Communicated by B. SAHNI.)

Riccardia Levieri was originally described by Schiffner from Bhutan in the E. Himalayas (Beiträge zur Lebermoosflora von Bhutan, 1899) and the diagnosis was included by Stephani (Sp. Hep. I, 261, 1900). Subsequently the plant was collected by Kashyap from the W. Himalayas and a description was published in the Journ. Bomb. Nat. Hist. Soc. 1917, and later in the Liverworts of the Western Himalayas and the Panjab Plain, Pt. I, 1929. All these accounts are confined to the vegetative characters of the plant and the archegonial branch.

In October 1935 *R. Levieri* was collected by the author from dripping rocks by the side of a stream in Ranikhet (Western Himalayas) at an elevation of about 7000′. The plants were in fruiting stage and bore the sex-organs and the sporogonia of different ages. In many cases characteristic bicellular gemmæ have also been observed. The species is not strictly dioecious but may bear the antheridia and archegonia on the different branches of the same plant. The development of the sex-organs and the sporophyte has been traced through various stages of development.

24. On some epiphyllous liverworts from South India.

S. K. PANDE *and* R. N. MISRA, Lucknow.

The epiphyllous liverworts of India, so far as the authors are aware, have not been investigated. In these notes are recorded a few observa-

[1] This paper was not formally presented, but the abstract is included as there was some discussion on it.

tions on some of those found growing on dicotyledenous leaves collected by Mr. H. S. Rao in June 1934 from near Gersoppa falls (Mysore State) at an elevation of about 1500′. The material was fixed in 90% alcohol and is in excellent state of preservation. Detailed investigation of the two folliose liverworts is in progress and the results are communicated in this paper.

1. *Leptocolea Gœbelii* var. *Arcrotremæ* (?) (Schffn.) *Loc.* Gersoppa falls. *Habitat.* Thick and leathery dicot. leaves. *L. Gœbelii* has previously been described from Java by Goebel (Ann. du Jardin Bot. de Buitenzorg, VII, 49, 1888) and also by Schiffner (Nova Acta, LX, ii, 240, 1893) who instituted the variety *Acrotremæ*. The specimens were found growing on the leaves of *Acrotrema Wightiana*. Stephani who raised the variety to specific reak gives its distribution as Pulo Penag, East India (Vide Sp. Hep. V, 847, 1912-1917).

In our specimens from South India *L. Acrotremæ* forms more or less open colonies, measuring about 5 cms. in each direction, on the upper surface of the leaf. Young sporophytes of different ages are quite abundant but no antheridia have so far been observed.

2. *Lejeunea* sp. *Loc.* Gersoppa falls. *Habitat.* Thick and leathery dicot. leaves. This hepatic may occur associated with *Leptocolea Acrotremæ*? or in separate colonies similar to those of the latter. It is monoecious and bears sporophytes in various stages of development and old antheridial shoots.

3. *Riccardia Levieri* Schffn. *Loc.* Garsoppa falls. *Habitat.* Thick and leathery dicot. leaves. A few sterile specimens of this liverwort were found mixed with *Leptocolea Acrotremæ*? and *Lejeunea* sp.

25. On the morphology of *Sewardiella tuberifera* Kashyap.

S. K. Pande *and* R. N. Misra, Lucknow.

Our knowledge of *Sewardiella tuberifera* Kash., a monotypic West Himalayan liverwort, has so far been confined to the contributions of Kashyap (New Phyt. XIV, 5, 1915, and the Liverworts of the Western Himalayas and the Punjab Plain Pt. I, 1929 and Pt. II, 1932) and Chalaud (Ann. Bryo. V, I, 1932). None of these accounts, however, gives the details of the life-history. The genus is of special interest because of its intermediate position between the thallose and the leafy hepaticæ. While emphasising its resemblances with *Fossombronia*, Kashyap observed that '*Sewardiella* may be said to be a condensed *Fossombronia*.' A detailed investigation was therefore undertaken by the authors with the hope that additional facts so obtained may be helpful in the better exposition of the relationship of this liverwort.

S. tuberifera is a dioecious species as reported by Kashyap and the antheridia and the archegonia are borne on the dorsal side of the midrib and a dozen or more may occur together. Mixed with these are found scales. The development of the sex-organs and the sporophyte is described. The relationship of the genus is also discussed.

26. Notes on Indian Hepatics. III.

R. S. Chopra, Lahore.

27. Chromosome numbers in some members of the *Codoniaceæ*.

P. N. Mehra, Lahore.

28. A *Notothylas* with sporogonia on the under-surface.

A. C. JOSHI, Benares.

In Anthocerotales, the archegonia, antheridia and sporogonia so far have always been seen only on the upper surface. In some specimens of *Notothylas* collected from the Central Provinces, however, the sporogonia have been found to arise from the lower surface from among the rhizoids. Further, they always protruded far out of the involucre Otherwise the specimens agree with *Notothylas indica*.

Pteridophytes

29. The study of male gametophyte and spermatogenesis of *Marsilia* from Poona.

G. G. KOLHATKAR, Poona.

(*Communicated by* G. P. MAZUMDAR.)

The life-history of the Indian species of *Marsilia* has been studied partially by S. S. Pande from Lahore. His work does not include the detailed study of the gametophyte, and it is now recorded that :—

(1) No gametophytes could be found under natural conditions, but they were obtained by germinating the spores in the laboratory.

(2) The development of the male prothallus and the four spermatogenous mitotic divisions were studied. The occurrence of the second sterile-cell conforms to the observations of Belajeff rather than those of Sharp.

(3) Centrospheres were observed in all the four spermatogenous mitoses. In the spermatid the centrosome was seen near the nucleus. This confirms the suggested transformation of a centrosphere into a blepharoplast as stated by Sharp.

30. Dichotomy as the probable cause of the so-called abnormalities in *Ophioglossum*.

T. S. MAHABALE, Poona.

It was pointed out by the author that the fertile spike and the sterile lamina are variable structures in *Ophioglossum*. (*vide* Proc. Ind. Sc. Con., 1934). Since then the author has collected about fifty different specimens showing abnormalities. These specimens were collected from places where normal plants could also be found under identical conditions of life, and it is therefore doubtful whether they can be considered abnormal. It is suggested that they all conform to a general primitive type of a dichopodium, of which they are further modifications. If this is so then the fertile spike and the sterile lamina are structures of the same kind and equivalent, *viz.* pinnæ, and these abnormalities support the pinna-theory of the fertile spike of *Ophioglossaceæ*.

31. The fertile spike of *Ophioglossaceæ*.

T. S. MAHABALE, Poona.

The paper discusses the various theories as regards the fertile spike of *Ophioglossaceæ*, and tries to point out that the pinna-theory is more in accordance with all the known facts at present than the other theories. Some fresh evidence has been adduced in the paper in support of the pinna-theory on the basis of the vascular anatomy and the early development of the fertile spike which was studied in *O. aitchisoni*, *O. fibrosum*, *O. vulgatum*, *O. gramineum*, and some other species. The early development of the spike shows that it is derived from a phyllopodium with a single

celled growing point, which divides dichopodially and forms two pinnæ. One of these develops earlier than the other and forms the sterile lamina while the other develops later on and forms the fertile spike. Vascular supply to the second pinna which becomes the spike is established secondarily. It therefore appears that the fertile spike of *Ophioglossum* is a second pinna of a dichopodial axis, the sterile lamina being the first one. These observations provide direct evidence in favour of the pinna-theory.

32. The gametophyte of *Ophioglossum aitchisoni* d'Alm.

T. S. MAHABALE, Poona.

Ophioglossum aitchisoni, d'Alm is a widely distributed species of *Ophioglossum* in the Bombay Presidency. The gametophyte was collected from different localities and studied since its discovery by the author in 1930.

The gametophyte is subterranean, slender and mycorrhizic. It is found in open grassy turves, where the soil is poor in humus content but somewhat rich in calcium. It is 0·2 to 2·5 cm. long, 0·1 cm. broad, pale yellow or brown in colour and profusely hairy. Its form is often cylindrical, with a distinct ' primary tubercle ' at the base, infected by a symbiotic fungus. The apex is blunt, single celled and free from the fungus. The gametophyte may branch, sometimes dichotomously. Apices of the branches reach the surface of the soil, turn green and form cellular cushions in which antheridia are occasionally developed.

Antheridia and the archegonia are formed on the same prothallus and are radially distributed. Antheridia appear first and lie near the growing point. Their walls are one celled and blepharoplasts are recognizable. Archegonia lie irregularly below the antheridia. The neck canal cell is binucleate and without any wall. In embryogeny the root is developed first and the sporophyte arises secondarily on it. The gametophyte is perennial and can propagate vegetatively by the detached branches.

33. The gametophyte of *Ophioglossum fibrosum* Schum.

T. S. MAHABALE, Poona.

The subterranean gametophyte in this species is found on open, wet grassy slopes on rocks. It is fleshy and more slender than that of *O. aitchisoni.* It is not very variable in form. Usually it is peg-like or worm-like in form. It does not appear to be perennial. It is 0·2 to 1 cm. long, 0·2 to 0·25 cm. broad at its upper end. It is pinkish and may turn green whenever exposed to sunshine. There are unicellular hairs on it, through which the mycorrhiza enters.

Both kinds of the reproductive organs appear on the prothallus and are sunk more deeply in the tissues of the thallus than in the other species. The gametogenesis is at present under investigation. The sporophyte makes an early appearance on the gametophyte and in such cases the root and the shoot appear to develop simultaneously. Vegetative propagation was not noted.

34. The gametophyte of *Ophioglossum pedunculosum* Desv.

T. S. MAHABALE, Poona.

O. pedunculosum Desv. is one of the little known species of *Ophioglossum* in India. Hooker has made a passing reference to it in his Synopsis Filicum on page 466, as occurring in peninsular India. Plants were collected near Poona, from waste land full of decaying material and organic debris. The gametophytes were collected from the same locality.

The gametophyte is subterranean and intensely mycorrhizic. It is pale white, at times yellow, 0·2 to 0·6 cm. long and 0·2 cm. broad, and

extremely variable in form. It may be round, cylindrical, much convoluted or lobed. It is thick and brittle and bears short rounded hairs. There is a large round or lobed 'primary tubercle' at the base. The prothallus may branch irregularly and bear gemmæ at the apices and so propagate the gametophyte vegetatively.

The antheridia and the archegonia are produced in large numbers and their development is easy to follow. The spermatocytes are more numerous in this species and the blepharoplasts always observable. Archegonia are half embedded in the thallus. The sporophyte arises as a secondary bud on the precociously formed root. The gametophyte is perennial.

35. Vascular system of *Osmunda cinnamomea*.

P. C. Sarbadhikari, Colombo.

36. Cytological investigation in the apogamous life cycle of *Adiantum lunulatum* Burn.

P. N. Mehra, Lahore.

37. Chromatin material found in the microspores of *Azolla pinnata*.

B. N. Mulay, Karachi.

The granular material found in the ripe microspores increases with the size of the spore and persists until the death of the spore. Various microchemical tests were tried to make out the nature of this material. The tests were negative for starch or oil globules. Feulgen's specific test for chromatin gives a positive result and proves that the material is of nuclear nature.

38. Morphological nature of the compound leaves of ferns.

G. P. Majumdar, Calcutta.

The continued apical growth, origin of buds in the axils of leaflets, dichotomous branching and also fossil evidence—all point to the *branch* nature of these members.

Angiosperms: 1. Morphology

39. A note on the variations in leaf-form of *Coffea arabica*.

L. N. Rao, Bangalore.

40. Studies in plant teratology.

B. C. Kundu, Rajshahi.

41. An abnormal type of ovule in *Eugenia jambolana* Lamk.

N. K. Tiwary, Benares.

42. Further observations on internal proliferation in *Carica papaya* Linn.

M. Sayeeduddin *and* A. Bari, Hyderabad (Deccan).

Within normal fruits of *Carica* were found small fruits, and in one of the parent fruits quite a big more or less oblong young fruit was found

attached by a stalk to the centre of the parent fruit. It bears the normal style and stigmas at the top. Longitudinal and cross sections have been studied. There is a single cavity and the ovules are parietal in position. Further, the cross sections of pericarps of the outer and inner fruits reveal an identical structure. View is expressed that those inner fruits which contain seeds are true pistils and those devoid of seeds are solid carpels resembling pistils.

43. A remarkable case of abnormal inflorescence in *Brassica campestris* var. *sarson* Prain.

T. C. N. SINGH, Sabour.

44. Studies in the classification of Bihar mangoes.

T. C. N. SINGH, Sabour.

45. Value of the study of epidermal structures of the leaf and fruit-skin in the identification of mango varieties.

(MISS) R. SHAH, Sabour.

46. Vivipary in the seeds of some fleshy fruits.

B. C. KUNDU, Rajshahi.

47. Germination of the bulbils of *Remusatia vivipara* Schott.

T. S. MAHABALE *and* G. S. DESHPANDE, Poona.

This aroid is found growing in clefts of tree trunks in shady parts of the jungles of the Western ghats. It makes its appearance in monsoons only and seldom flowers. There is a single peltate leaf, encircled by three to four phototropic shoots sprouting from the corm. The shoots bear scaly leaves at each node, and not flowers as the appearance would suggest. The scaly leaves are pierced by a large number of oblong bulbils at each node. The course of their germination is followed through transitional forms till the bulbil attains the cormatous habit so characteristic of the adult plant.

48. Pneumatophores of *Jussieua suffruticosa* Linn.

T. S. MAHABALE *and* V. G. BAVADEKAR, Poona.

Jussieua suffruticosa is occasionally found growing along the margins of fresh water pools, canals and the rivers round about Poona and Londa. Like other well known species of *Jussieua*, e.g. *J. repens*, *J. peruviana*, this species forms pneumatophores under certain conditions. Whenever the plant grows in sand or in the soil, it forms normal roots only, but if it grows in water, it forms secondary roots which contain aërenchyma profusely. These roots are soft, spongy, negatively geotropic, and float in water with their vermiform pink apices just protruding above the surface.

The paper gives an account of the external as well as internal morphology of these pneumatophores and compares them with the normal roots of the same plant and similar organs of the other species.

49. Observations on the aerial roots of *Sorghum vulgare* Pers.

N. K. TIWARY, Benares.

50. Studies in the polycotyledonous seedlings of Angiosperms.
T. C. N. Singh, Sabour.

51. A monograph on the *Apocyanaceæ* of Dacca.
H. K. Datta, Dacca.

The plants, mentioned in this paper and the following one, all belong to the red soil of Dacca, So far as my observation goes, these plants also include almost all those of the alluvium of Dacca. In preparing the diagnostic tables, I have followed, with slight modification, the methods of Hooker and Prain. In the family Apocyanaceæ, there are 15 species, arranged in 14 genera.

52. A monograph on the *Convolvulaceæ* of Dacca.
H. K. Datta, Dacca.

In this family there are 17 species belonging to 9 genera. Special mention is made of the useful and medicinal plants of both the families. Identification keys are given.

53. Multicarpellary pistils in *Cassia auriculata* Linn.
J. Venkateswarlu, Benares.

54. Cyto-genetical evidence of the hybrid origin of *Oryza minuta* Presl., an octoploid species.
H. K. Nandi, Calcutta.

55. Effect of temperature on the formation of diploid gametes in *Oryza sativa* L.
H. K. Nandi, Calcutta.

Angiosperms: 2. Cytology

56. Chromosome studies in *Saccharum arundinaceum* L.
E. K. Janaki Ammal, Coimbatore.

Forty chromosomes—10 large, 10 medium and 20 small—were found in root tips of *Saccharum arundinaceum* collected near Coimbatore. Their behaviour at meiosis was studied and the nature and frequency of their chaisma noted.

57. Embryological studies of *Browallia elata* Linn.
P. N. Bhaduri, Calcutta.

58. Meiosis in the pollen-mother-cells of *Hibiscus Rosa-sinensis* L.
N. K. Tiwary, Benares.

59. Notes on the life-history of *Cleome viscosa* L.
N. K. Tiwary, Benares.

60. Somatic cell-division in *Hibiscus Rosa-sinensis* L [1]

N. K. TIWARY, Benares.

Plants growing in Benares are all sterile. Their sterility has been traced by one of the writer's students to defective gametogenesis. The present study was undertaken to see if there were any anomalies in the mitotic process as well. Although no special anomaly has hitherto been discovered, a number of interesting points in the details of the process have been noticed and are described.

61. Origin and development of the adventitious embryos in *Eugenia jambolana* Lamk.

N. K. TIWARY, Benares.

62. Somatic cell division in the root-tips of *Eugenia jambolana* Lamk.

N. K. TIWARY, Benares.

63. Development of the embryo-sac in *Aloe.*

A. C. JOSHI, Benares.

According to Gioelli, the embryo-sac in the genus *Aloe* develops according to the *Lilium*-type, that is, directly from the megaspore mother cell and without the formation of any megaspores. A study of the embryology of *Aloe vera,* however, shows the regular formation of megaspores, the chalazal one out of which gives rise to the embryo-sac. The tetrad of megaspores when complete is T-shaped. More commonly the division of the nucleus in the micropylar dyad cell is not followed by wall formation and only three megaspores are formed, out of which the micropylar is 2-nucleate.

64. A study of pollen in the *Thymelaeaceae.*

A. C. JOSHI, Benares.

Morphology of the pollen of *Thymelaea arvensis, Wickstroemia indica* and *Daphne mezeurum* has been studied. The mature pollen grains have been found in every case to be three nucleate and the male gametes are in the form of cells. Tapetum develops from the innermost parietal layer. Other characters of the anther wall are also described.

65. Development of the embryo-sac in *Punica granatum* Linn.

J. VENKATESWARLU, Benares.

(*Communicated by* A. C. JOSHI.)

The primary archesporium in the ovule is commonly more than one-celled, though usually only one of them is functional. It cuts off the parietal cell and becomes the megaspore mother cell. The latter divides twice to form the linear tetrad. The chalazal megaspore functions to form the embryo-sac. The development of the embryo-sac is normal. The mature embryo-sac is 4-nucleate due to the early degeneration of the antipodals. Degenerations in all stages of the embryo-sac have been observed.

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[1] This paper was not formally presented, but the abstract is included as there was some discussion on it.

Angiosperms: 3. Anatomy

66. The systematic anatomy of Bengal Cucurbitaceæ—II.

P. N. Mazumdar *and* J. N. Mitra, Dacca.

67. On the endophytic system of *Arceuthobium minutissimum* Hook. f.

S. P. Agharkar *and* R. M. Datta, Calcutta.

Arceuthobium minutissimum Hook. f., is a parasite on *Pinus excelsa*, Wall. The material was collected by the senior author during his trip to Muktinath in Nepal in June 1923, and preserved in formalin. The plant ramifies entirely within the cortex producing minute branches which perforate but scarcely rise above the surface, appearing as a 2-lipped cup, male flowers being sessile in the cup, 3–5 partite and female flowers being pedicelled.

The endophytic system consists of filamentous and parenchymatous cells with large nuclei. They run more or less longitudinally in the cortex of the host, branch freely in all directions in the phloem, the medullary rays and wood, causing hypertrophy of the invaded tissues. Some of the cells appear to enter inside the tracheids by corroding their sides.

In addition to these, reticulate tracheids are found in the region where the parasite forms sinkers. No phloem is found.

Details of the anatomy will be embodied in the paper.

68. Floral anatomy of *Wickstrœmia indica.*

A. C. Joshi, Benares.

Vascular anatomy of the flower of *Wickstroemia indica* agrees with that of *Stellera Chamæjasmæ* described previously and supports the bicarpellary interpretation for the gynæcium.

Physiology and Ecology

69. Studies on some aspects of the water-relations of the cotton plant. Part I.

T. Ekambaram *and* C. Jagannatha Rao, Madras.

From a physiological study of the effect of three different percentages of soil moisture, namely 15, 20 and 30 per cent., on the transpiration and growth of two different pure strains of indigenous cottons, namely, C. 7 (*karunganni—Gossypium indicum*) and H. 1 (Westerns—*G. herbaceum*) grown in them during 1934-35 under suitably-devised pot-culture conditions in the green-house at the Presidency College, Madras, certain tentative indications are forthcoming. Total loss of water due to transpiration, out-put of dry matter from the root region, from the plant-stalk or stem and from the leaves are found to follow the order of the moisture percentages of the soil. Similar has been the behaviour of height of shoot, of the number as well as the average length of internode and of both the total number of leaves per plant and the average area per leaf.

70. Effect of gases, from brick kilns, on mango crops.

N. L. Pal, U. N. Chatterji, *and* S. Ranjan, Allahabad.

Gases emanating from brick kilns cause a great deal of damage to plants owing to the partially oxidised products of coal contained in it.

The effect of these gases on mango crops consists in (1) formation of black spots (which gradually hardens as the fruits age) towards the distal end of the fruits, (2) retardation of growth of fruits, and (3) their falling off before attaining maturity. A chemical examination of the damaged fruits showed that these were physiologically more ripe than the undamaged ones. This physiological ripening process before the maturity of the fruits cause early senescence and consequent shedding. Though most of the fruits of the garden examined were damaged, the trees and their foliage in general seemed healthy.

71. The economic importance of changes in plant cover.

R. Maclagan Gorrie, Lahore.

(*Communicated by* H. G. Champion.)

Similarity of land use problems in India and U.S.A. is demonstrated and object lessons already learnt in the States applied to Indian conditions, *e.g.* more rational use of non-plough land to conserve grazing resources and water supplies. Importance of managing hill catchment areas primarily for their value as catchments—*e.g.* the Uhl river supplies the Punjab hydro-electric plant from a 200 square mile catchment, revenue from which is 3 pies per acre as compared with investment amounting to Rs.550 per acre for electric plant, the security of which depends entirely upon behaviour of stream.

The value of plant cover as the major factor controlling stream flow is emphasised by describing the process by which seepage of surface water through soil layers builds up underground reserve for perennial springs. Porosity of soil and its capacity to allow seepage depend upon the condition of the soil profile. Maximum seepage is provided by profiles maintained by the ecological climax vegetation. Whatever reduces protective value of the plant cover interferes directly with the porosity of soil. In India, the chief cause of this is heavy grazing.

Data are quoted for 3 grades of plant cover density in the Pabbi Hills (Punjab) showing the flood intensities which originate from :—

(i) land treated by afforestation and active counter-erosion work; this gives less than 100 cusecs per square mile maximum flood, and renders cultivation possible up to edge of small stream channel;

(ii) land protected by partial closure to grazing, this gives 600 to 700 cusecs per square mile, with correspondingly rapid and dangerous flood peaks, rendering cultivation impossible inside a wide flood channel;

(iii) unprotected land constantly over-grazed which gives a maximum flood intensity of 1,600 cusecs per square mile.

72. Studies in the ecology of the *Shola-grassland* vegetation of the Nilgiri plateau.

G. C. Ranganatha, Ootacamund.

(*Communicated by* H. G. Champion.)

The natural vegetation of the plateau is a mixture of temperate evergreen forest (shola), its seres, and grass. The grasslands are very extensive and are practically confined to the western plateau which is subject to annual ground frosts. Here the shola is reduced to small isolated woods occupying folds and hollows on the slopes. The shola is relatively abundant on slopes protected from the morning sun. The absence of fringing forest along perennial water courses is a feature of the frost zone. The study of altitudinal zonation shows the shola to be the

forest climax. Various considerations, such as its known antiquity and stability, indicate that the grass is also a natural climax. The relative distribution of the two climaxes is governed by the incidence of frost. Frost damage on the Nilgiris is confined to young plants and is probably a form of wilting effect due to plants exposed to the morning sun being unable to draw water from the frozen soil. The shola occupies slopes protected from the morning sun and sites where the danger of freezing is neutralized by abundant moving soil water. The grass though destroyed by frost revives quickly owing to its perennial root stock and its ability to spread vegetatively.

73. Short cut to the nectaries in *Bauhinia purpurea.*

L. N. RAO, Bangalore.

74. Further studies in the pollination in Sunn-hemp.

T. C. N. SINGH, Sabour.

75. Birds in relation to angiospermous flowers.

T. C. N. SINGH, Sabour.

76. Observations on plants raised from the seeds of white-flowered *Urena* Dill. ex L.

N. K. TIWARY, Benares.

77. Some more unrecorded hosts of *Loranthus longiflorus* Desr. from Hoshiarpore (Punjab).[1]

P. C. JOSHI, Lahore.

The following hosts of *Loranthus longiflorus* are recorded from the submontane tract of Hoshiarpore which, most probably, have not been mentioned for this species from any part of India so far—*Acacia arabica* Willd., *Acacia modesta* Wall., *Cordia obliqua* Willd., *Grewia oppositifolia* Roxb., *Murraya exotica* Linn., *Salix tetrasperma* Roxb. and *Phyllanthus Emblica* Linn.

78. On the occurrence of *Aldrovanda vesciculosa* Linn.

J. C. SEN GUPTA, Calcutta.

79. On the flora of Bakarganj Sundarbans.

J. C. SEN GUPTA, Calcutta.

80. Further contribution to the vegetation of Hyderabad (*Dicotyledons*).

M. SAYEEDUDDIN *and* M. A. SALAM, Hyderabad (Deccan).

Since the publication of the paper 'Some of the Flowering Plants of Hyderabad, their distribution, economic and medicinal importance' (*J.A.S.B.Sc.*, I, 1935, 1), a lot of material has been collected from different parts of Hyderabad, *viz.* Mulug, Pakhal, Nizam Sagar, Vikarabad and

[1] This paper was not formally presented, but the abstract is included as there was some discussion on it.

Aurangabad, some of which has been worked out. The present paper places on record some of the Dicotyledonous plants which have not been recorded so far from Hyderabad. The most interesting feature is that the two geologically and ethnologically distinct divisions of this extensive plateau present also a marked contrast in their vegetation, and thus provide a vast field for systematic and ecological study.

Altogether 73 species belonging to 32 families of Dicotyledons have been mentioned with brief notes about their habitats. The cultivated plants are omittod.

Palaeobotany

81. Studies on some silicified plant-remains from the Rajmahal series.

B. P. SRIVASTAVA, Lucknow.

(*Communicated by* B. SAHNI.)

The study of the following types is based on silicified material, belonging to the Rajmahal series of India, collected from Nipania, Santhal Parganas, Behar. (Srivastava, Proc. Ind. Sci. Congr., 1935 and Proc. Zesde Internat. Bot. Cong. Amsterdam, II, p. 248, 1935).

Part I.—On the anatomy of *Lycoxylon indicum* gen. et sp. nov., a stem with Lycopodium like stele.

Stems 1-2 millimeter in diameter. Stelar anatomy *Lycopodium* like, with about twenty protoxylem groups and very suggestive of *L. volubile* type. Phloem and phloem sheath not preserved. A circular gap (in a cross section) surrounds the stele and this is followed by a band of thick walled inner cortical cells. Stem decorticated. Outer cortex containing the leaf-traces and the clothing of leaf bases missing.

Longitudinal or oblique sections show scalariform pittings, as in the living genus.

If it is really a *Lycopod*, it is rather strange that the huge *Lycopods* of the Palæozoic were succeeded in the Jurassic by such diminutive types. The presence of *Lycopodium* has long been suspected in the Mesozoic, but till now all the species known occur as impressions (*Lycopodites*). This specimen after all may be a pertrified twig of *Lycopodites gracilis* (O. & M.).

To refer this Jurassic specimen to the genus *Lycopodium*, merely on the strength of its stelar character, may not be advisable. *Asteroxylon*, for example resembles *Lycopodium* in its stelar characters but its affinities are, as we know, entirely different. In view of this, the specimen under consideration has been referred to a new genus *Lycoxylon*.

Part II.—On *Pentoxylon Sahnii* gen. et sp. nov.—A new type of gymnospermic stem.

This is one of the commonest plant remains in the silicified flora of Nipania and is characterized by the presence of usually five vascular bundles, arranged in a ring in the ground-tissue.

Each vascular bundle consists of a lenticular mesarch primary portion. At first secondary growth follows equally around each one of these, but soon there is a tendency for a pronounced centripetal development of the secondary elements. Wood compact with well marked growth rings. One to three more or less wedge shaped branch traces, alternate with the bundles. Sclerotic nests are present in the ground-tissue.

Protoxylem tracheids have annular and spiral thickenings, while the secondary elements show uniseriate, contiguous, round bordered

pits. Summer tracheids of older wood, however, usually show a biseriate, contiguous, alternate pitting. Medullary rays uniseriate, usually 2–7 cells high. A single large pit in the field. Secondary phloem cells have tangentially thickened walls.

Sometimes there are six bundles instead of the usual five. Not infrequently one or a few of the bundles grow larger in size than the rest or may show a pronounced centrifugal growth of the wood.

Part III.—On *Nipanioxylon Guptai* gen. et sp. nov.

Stems with usually eight vascular bundles having equal secondary growth all round. Pith and cortex wide, 1–3 sets of more or less mesarch collateral traces traverse the cortex. Numerous sclerotic nests found in the cortex and pith. Xylem of the vascular bundles and the traces consists of scalariform tracheids. Radial pits of secondary tracheids uniseriate, circular, contiguous. Medullary rays uniseriate.

Several spherical stem pieces, hardly a few millimeters in diameter (5 mm. to 1 cm.), also show a wide pith, clearly delimited by 'a jacket of cells'. In the cortex are found eight vascular bundles, sometimes less due to fusion, often showing a centrifugal disposition of tracheids.

Part IV.—*Carnoconites*—a new genus of fleshy ovuliferous cones.

Generic diagnosis.—Strobili bearing several ovules with micropyles pointing outwards. Outer fleshy and stony layer well developed. Nucellus totally free from the integument. Megaspore membrane thick. Nucellar cone projects into the micropyle. Ovular supply terminates below the base of the nucellus. Female prothallus preserved in many cases. Few seeds contain the remains of an embryo.

Carnoconites sp. A. Compact cones about 2 cm. × 1 cm., bearing 5 to 6 ovules in each longitudinal row, sometimes very few. Fleshy layer 1·2 mm. broad. Cones borne on long stalks which emanate from a central axis. 3–5 mesarch vascular bundles traverse the stalk. Cone axis shows 5·6 mesarch bundles.

Carnoconites sp. B. Lax cones about 3 cm. × ·5 cm., with up to twenty ovules in each longitudinal row. Ovules smaller but more numerous in this species. Fleshy layer less developed, though distinct. On comparison with the original specimen, it seems to be the petrified specimen of what is known in impressions as *Strobilites Pascoei* Sahni.

SECTION OF ZOOLOGY

President :—GOBIND SINGH THAPAR, M.Sc., Ph.D.

Presidential Address

HELMINTHOLOGICAL RESEARCH IN INDIA

LADIES AND GENTLEMEN,

Allow me first of all to offer my thanks to the authorities of the Indian Science Congress for asking me to preside over this section. I believe that in selecting me for this honour, they had in mind the idea of encouraging a small band of amateur helminthologists working in India.

Whatever attention helminthology has received in India in the past has been mostly at the hands of medical and veterinary officers who, in the course of their routine work, were confronted with the worms, but in recent years there has been growing appreciation of the importance of the subject, which offers such a vast field for work of economic value to the country. The Government of India, a few years ago, recognized this by the creation of a post of helminthologist at the Imperial Veterinary Research Institute at Muktesar and a Professorship of Helminthology at the Calcutta School of Tropical Medicine. In Burma, the Government has provided a well-equipped Helminthological Institute for co-operative work. There was a provision for an up-to-date department of Helminthology in the All-India Institute for Medical Research, a proposal which unfortunately had to be given up for certain reasons. A considerable amount of work is, however, contributed by zoologists on the morphology and bionomics of helminths. The Zoological Survey of India have appointed a zoologist to work out their helminthological collection, though only in a junior capacity, and helminthology has been introduced as a special subject of study for the post-graduate and research classes at some of our Universities. The Imperial Council of Agricultural Research have recently financed a scheme on the helminthiasis of domestic animals, and the Universities are being approached to co-operate in the work. In this scheme, which I had the honour to initiate (originally for the United Provinces alone), I have been allotted the work in the United Provinces, Bengal, Bihar, Orissa and Assam. This recognition of the work of a professional zoologist is a healthy sign for the country, because the past records of other countries reveal that the solution of many fundamental problems of helminthology has been found at the hands of zoologists. The

study of helminthology involves a knowledge of many different groups of animals which act not only as the final or reservoir hosts for the adults but also as intermediate hosts of helminth larvæ. A zoologist, by his training in comparative anatomy, is specially fitted to carry on these studies.

In view of the growing significance of helminthology in medicine, public health, veterinary science and agriculture, no apology seems necessary for selecting as the subject of my address to-day 'The Needs and Opportunities of Helminthological Research in India'.

Importance of Helminthology.

Helminth parasites have, as we all know, been a source of affliction alike to man, domestic animals and plants. The tumours in the intestine, the granulations in human lung, hæmaturia, elephantiasis, ocular filariasis and the liver-rot are only a few of the diseases that are generally associated with the presence of these worms. There are a large number of parasitic worms causing various kinds of diseases and their number is constantly increasing as new forms are daily being discovered.

The application of zoological methods to the study of helminth parasites has revealed many important points for consideration, particularly with regard to their infections and subsequent eradication. Many of these parasites are injected into the body by insect bites, others penetrate the skin by their own activities, others, again, are taken into the system with contaminated water or food. All these factors could be obviated by the removal of the source of danger, so that refinements in sanitation will, undoubtedly, eradicate human parasites: in fact, '*Tænia solium* is said to have taken the road to extinction when the mythical Chinaman burned down his house, ate the incinerated pig and pronounced that it was good'.

But the case is different with domestic animals. The damage that parasites cause to livestock in India cannot be adequately estimated, as exact data are not available and very often their occurrence passes unnoticed. In the absence of systematic work many instances of death due to helminthic infections pass unrecorded. Sanitation for animals is limited and the restricted range of open pastures, by their gradual utilization for agriculture and human habitation, would naturally tend towards the overpopulation of stock animals over a limited area. Consequently there is increased danger of re-infection. Similarly, modern means of transportation, without quarantine regulations, would predicate the transportation of the parasites with the migration of the hosts.

Climatic factors also would affect the parasitism of livestock and here the rôle of hibernation in the incidence of parasitism can scarcely be ignored. Ideas on this subject are so conflicting

that extended observations under modern conditions would seem to be very necessary. Attention has been drawn to the fact that in domestic animals parasitism decreases in certain periods of the year, while it increases at other times ; in fact, it has been pointed out to me that tapeworm and fluke infections disappear in the Punjab during the hot months, but suddenly re-appear in the winter. Data were collected at Lucknow as well and it was noticed that there was increased parasitism of the stock animals during the winter months, a period corresponding to the hibernation of frogs and snakes. During monsoon months, however, stock animals carry very little helminth infection. This was explained on the assumption that during the monsoon months the eggs and larvæ of the parasites of the farm animals are likely to be washed away by the torrential rains and are thus prevented from reaching the final hosts.[1] After the rains, the larvæ reach their destination and by their faculty of asexual multiplication again establish themselves in the hosts. This explanation, however, will hold only for certain helminths ; further observations may explain other cases. In frogs and snakes chances persist for the re-entry of the parasites, as these animals generally hibernate in soil where the eggs or larvæ of the parasites are constantly present.

Helminths and Agriculture.

Various plant diseases—wheat cockles, potato sickness, stunted growth in clovers and the like—are likewise due to the ravages of helminths.[2] The causal agents belong to the nematode genera, *Anguillulina*, *Heterodera* and *Aphelenchus*. Even our sugar industry is affected by these parasites, which tend to destroy the crop of sugar-cane. Other kinds of infections by helminths occur in a variety of food plants. Even garden plants—violets, chrysanthemums, narcisuss, ferns and orchids—are not immune : the helminths enter the body of their plant hosts through the stomata or through the roots from the surrounding soil. No one now questions the serious losses incurred by the agriculturists and horticulturists through the agency of helminth parasites ; the causal agents are, as indicated earlier, usually individuals belonging to a well recognized group of Nematoda. A comparative study of these parasites promises illuminating results. A helminthologist will have to enquire into the important reservoirs of infections in weeds in the same way as he would investigate the reservoirs of infection for domestic animals.

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[1] Thapar, G. S.—*Parasitic Worms and Disease.* L.U. Series, No. 3, 1936.

[2] Goodey, T.—*Plant Parasitic Nematodes.* Methuen and Co., London, 1933.

Ancient Helminthology.

Before proceeding with some of the recent problems in helminthology it is fitting to introduce here a few words on the part played by our country in this field. The earliest references to the worms are to be found in Sûsruta, Charaka and Madhava Nidhana. Sûsruta gives an abstract classification of as many as twenty different kinds of worms, indicating their origin in fæces, phlegm and blood, and acquired as a result of the use of uncongenial and undigestible articles of food. The classification of Sûsruta, however, is vague and appears to include forms that evidently belong to classes other than the helminths. Owing to their incomplete diagnosis it is not possible to assign them a proper systematic position in our modern scheme of classification. The only worm that I have been able to identify is the *Dvimukha* of Sûsruta, which is *Enterobius vermicularis.* There are references to *Parisarpa* and this I believe to be the *microfilariæ* or allied forms in the human blood. Charaka describes the origin of these worms from external filth and also mentions those that are present from the very birth. Madhava Nidhana mentions *Udarada* or *Udaravasta* and this Wilson regards as tapeworms.

A few references to helminths of domestic animals are likewise found in Asvavaidyaka, where it is mentioned that horses are attacked by worms in all seasons except the monsoon, when infection takes place through drinking water. The infection is usually associated with the appearance of the moon and a suggestion is made that the treatment should also be started on the same day of the month. How far the motions of the moon are connected with the infection and the subsequent treatment and cure of the worm infestation in animals is a question worthy of investigation, as there are similar references to worm infestation in man in the ancient literature of India. There is still a common belief in this country that the painful itching sensation at the vent in children, due to the presence of *Enterobius vermicularis,* is associated with the appearance and disappearance of the moon. The nocturnal appearance of *Wuchereria* embryos, however, in the human blood is well known.

There are other similar evidences in the ancient Hindu literature to show that the worms are the oldest recognized group of parasitic organisms that seriously affect man and his domestic animals. But on the whole the study of animals and their parasites does not seem to have progressed very far in ancient India. For this, I believe, the responsibility rests mainly on the humane attitude of the Hindus towards animals. Quite a number of animals are deified by them but even apart from this fact, the doctrine of ahimsa must have exerted a strong influence against all zoological studies in ancient India. Relics of

this abhorrence of killing for the sake of study still persist amongst our university students, who sometimes hesitate to open an egg for the examination of the chick embryo.

Present Position.

It was not till 1829 that Hodgson introduced zoological studies in India but helminthology still did not receive recognition in the research activities of the zoologists. Credit for the earlier work in helminthology, however, goes to a band of enthusiastic officers of the medical and veterinary services who recorded valuable observations on helminths during their routine duties. Gaiger, Clayton Lane, Stewart, Sewell, Ware and Sheather are amongst the prominent workers in the field. The authorities of the Indian Museum sent out, from time to time, collected materials to European specialists for reports. Some of these reports were necessarily incomplete and defective in many ways and much revision seems necessary. Valuable contributions on the helminths of fishes have been made by Southwell and Prashad from the Indian Museum in Calcutta.

The position, at present, with regard to helminthology in India is that, apart from a few stray contributions by members of the medical and veterinary professions, there are only scanty references on the subject: the rich helminth fauna of India remains practically unexplored. But the foundation for a systematic study of the helminths as laid by these workers offers ample scope for rapid progress in the work in its different aspects.

Defects in Teaching.

But there are certain difficulties in providing adequate knowledge of helminthology to our students in the laboratories. For the classification and description of helminths we depend upon British text books, which still retain old nomenclature, now considerably modified as the result of recent work. Thus, for instance, such standard works as those by Parker and Haswell (1930) and Sedgwick (1927), though they claim to have been carefully revised and brought up to date, still continue to use old and antiquated names. In the majority of cases tapeworms are still referred to as species of the old genus *Tœnia*, the name *Tœnia echinococcus* is used for *Echinococcus granulosus*, *Tœnia cucumaria* for *Dipylidium caninum*, *Taenia coenurus* for *Multiceps multiceps*. Some of our university teachers still use the generic name *Tœnia* for a variety of tapeworms obtained from our common pigeons in the laboratories. In Nematode nomenclature similar examples are: *Oxyuris* for *Enterobius*, *Filaria* for *Wuchereria*, *Dochmius* and *Uncinaria* for *Ancylostoma*, *Rhabdonema* and *Rhabditis* for *Rhabdias*.

Even the descriptions of the life history of such a common worm as *Ascaris* are inaccurate and confused in these books.

While it is true that the infection is direct (as a contamination of food, and not water borne), it has long been established that the *Ascaris* larvæ, on being released by the action of the digestive juices in the alimentary canal, pierce through the gut wall and before establishing themselves as adults in the intestine, undergo a long and weary pilgrimage through the liver, blood stream, heart and lungs. Here they enter the air sacs and pass up the bronchi to be brought back to the intestine to assume the adult characters.

An error in describing the structure and biology of a free living species would not be so serious, but a similar error in describing a parasite would confuse the diagnosis of the disease caused by it and may even hamper the treatment and the application of preventive measures.

Another serious defect in our present-day teaching is the choice of examples in helminthic studies. Generally human parasites are selected and this gives the student the wrong impression that helminthology is "a specialized medical curriculum". This is obviously undesirable, as it puts the student off the subject for the remainder of his career.

As was suggested by Professor Leiper some years ago, the subject should be taught practically so that a student may realize that parasitism is one of the commonest biological phenomena in nature. Helminthology should be introduced into zoological studies only to explain, with the help of simple types, the phenomenon of parasitism. The student should collect helminths from his own dissection animals. Collections made by the student himself will naturally excite his interest in the subject and he will find ample scope for original work in helminthology. As regards the choice of examples, it may be suggested that *Rhabdias* as a type of studies of nematode and *Raillietina* of cestodes would form very convenient substitutes for the human types studied at present.

Morphology.

There is a growing need for work on the morphology of helminths, as there is a considerable helminth fauna still unexplored in India. There are groups that need extended studies at the hands of specialists. To a worker not adequately trained in the field many forms in a group present a relatively uniform appearance, and he, in his enthusiasm to describe new forms, has added confusion. Quite a number of forms have recently been described under *Tachygonetria* and *Thelandros* and in one case as a new genus, *Parapharyngodon*, by young enthusiasts, without, however, understanding the diagnosis of the forms already known. These new generic and specific names have caused much confusion in the nomenclature. The two genera, *Tachygonetria* and *Thelandros*, differ from each other, as was

suggested,[1] mainly in the character of the genital papillæ. This conclusion was based upon a study of the original type material several years ago from the Vienna Museum and subsequently confirmed as a result of my observations on a large number of forms from the reptiles. It is to be regretted that Bayliss[2] has maintained, about the characters of *Thelandros*, the confusion that was cleared up several years ago.

One of the most important characters of the nematode worms that has long been recognized is the absence of cilia at any stage of their existence and on this assumption the group was considered by Shipley to be closely related to Arthropoda. During recent years, the presence of cilia has been demonstrated by several workers in the intestinal lining of several genera of nematode worms. They have been variously described under 'bordure en brosse' (Prenant); 'Stäbchen' (Martini); 'Stäbchenlage' (Jägerskiöld); etc.. Hetherington[3] has definitely shown them all to be modified forms of cilia and further regards the presence of cilia, particularly the external ciliation, as a primitive character, its loss being due to the tendency of cuticularization. I have also observed external ciliation in certain Oxyurid worms of the genus *Pharyngodon*, guarding the excretory pore.

Another character of systematic importance in nematode worms that has been considered valid is the nature of the œsophagus and the families, Ascaridæ and Oxyuridæ, are differentiated from each other in having one or two œsophageal bulbs. While investigating the reptilian oxyurids, I came

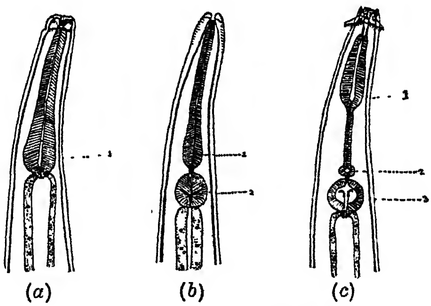

FIG. 1. Anterior end of (*a*) *Ascaris*, (*b*) *Enterobius* and (*c*) *Labiduris* showing the œsophageal bulbs 1, 2 and 3 in the families Ascaridæ, Oxyuridæ and Labiduridæ respectively.

across a rather unusual form, *Labiduris*, which on a detailed

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[1] Thapar, G. S.—Reptilian Oxyurids. *Journ. Helminth.*, vol. III, 1925.

[2] Bayliss, H. A.—Nematoda, vol. I in the *Fauna of British India*, 1936.

[3] Hetherington, D. C.—Comparative studies on certain features of Namatodes and their significance. *Illinois Biological Monographs*, vol. VIII, 1923.

examination, revealed the presence of a triple-bulbed œsophagus. This led to the modification of its systematic position in conformity with the prevailing practice for the two families cited above. A new family, Labiduridæ, was thus created for the reception of this old form. Yorke (1925), in a private communication, confirmed this view.

I regret to bring these controversial points before you here to-day, but my only justification is to show the great possibilities that await us even in the re-investigation of the described forms. The chief problem in helminthology to-day is the elimination of errors which have unfortunately crept into the earlier literature and are responsible for confused ideas concerning even the distribution of the parasites. All collections should, therefore, be restudied to clear up the existing confusion.

Amongst the Trematodes, Sinha has recently re-investigated the genus, *Xenopharynx*, whose systematic position has been the subject of long controversy ever since its original author, Nicoll,[1] placed it under the family, Dicrocoelidæ. Khalil[2] transferred it to Telorchidæ, but Bhalerao[3] brought it back to the family Dicrocoelidæ, and thus confusion arose. A comparative study of the morphology of the Reptilian Trematodes by Sinha goes in favour of the inclusion of this genus in the family Plagiorchidæ. Again the recent work of one of my colleagues[4] on the family Notocotylidæ has shown the relative value of various characters in the members of this family. Lal, in these investigations, has further justified the question of re-investigation of described forms for elimination of the existing errors. I cannot pass without a reference to the useful work on similar lines done by Mehra and Varma at Allahabad, Mirza at Aligarh and Bhalerao at Muktesar. Their persistent efforts have shown the extensive opportunities which helminthological research offers in India.

Classification and Relationship.

Closely associated with morphology is the classification of the helminth parasites which is in urgent need of revision. For instance, the earlier classifications of that neglected group of worms, the Acanthocephala, were based, amongst other features, upon the characters either of the nuclei in the hypoderm and lemnisci or of the prostate glands. Neither of these characters

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[1] Nicoll, W.—Trematodes from Indian cobra. *Proc. Zool. Soc.*, 1912.

[2] Khalil, M.—Trematodes from *Naja bungarus*. *Journ. Helminth.*, vol. I, 1923.

[3] Bhalerao, G. D.—Trematodes from water snake. *Parasit.*, vol. XVIII, 1926.

[4] Lal, M. B.—Review of the genus *Notocotylus*. *Proc. Ind. Acad. Sci.*, vol. II, 1935.

seems to be reliable. Southwell and Macfie[1] offered severe criticisms on both these systems, but were unfortunately unable to avoid for a portion of their work, the classification based on the nature of the prostate glands, which is characterized by them in the following words :—

'. . . . . No reliance can be placed on the appearance of the prostatic glands of young worms. In mature worms it is frequently extremely difficult to determine their number. . . . . . Our experience has convinced us that the shape and arrangement of the prostatic glands are by no means constant and as diagnostic characters must not be pressed too far, only differences of considerable degree being significant.' A character was finally discovered that would satisfy a large majority of cases. The nature of the proboscis hooks was found to present constant variations in the group and this character along with the body spines formed the basis of the tentative classification given for the group in 1927.[2] It is true that the body spines may, at times, fall off as stated by several workers, but the proboscis hooks are always present and exhibit variations in their roots in the proboscis wall. They are quite apparent even at a superficial examination, and Meyer[3] found amongst other characters, constant differences in the arrangement of the proboscis hooks, and advocated this feature as of primary importance in the classification of Acanthocephala. As regards the body spines, their presence or absence was used as a diagnostic character independently by Van Cleave (1928) when he erected the families, Pallisentidæ and Hebesomidæ. More recently, the same author[4] has created the new sub-orders Gyracanthocephala and Neoacanthocephala on the basis of this character. All this lends further support to the tentative classification then proposed for this group.

With the accurate study of morphology and the establishment of a natural system of classification for the helminth groups, the problem of evolution and the relationships of various groups of helminths would naturally arise. Thus Sewell,[5] as a result of his extensive studies on the Indian Cercariæ spread over a period of several years, indicated the polyphyletic origin of the furcocercous cercariæ. This helped to explain the relationships of the families, Strigeidæ and Schistosomidæ with each

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1 Southwell and Macfie.—Collection of Acanthocephala in the Liverpool School of Tropical Medicine. *Ann. Trop. Med. Parasit.*, vol. XIX, 1925.

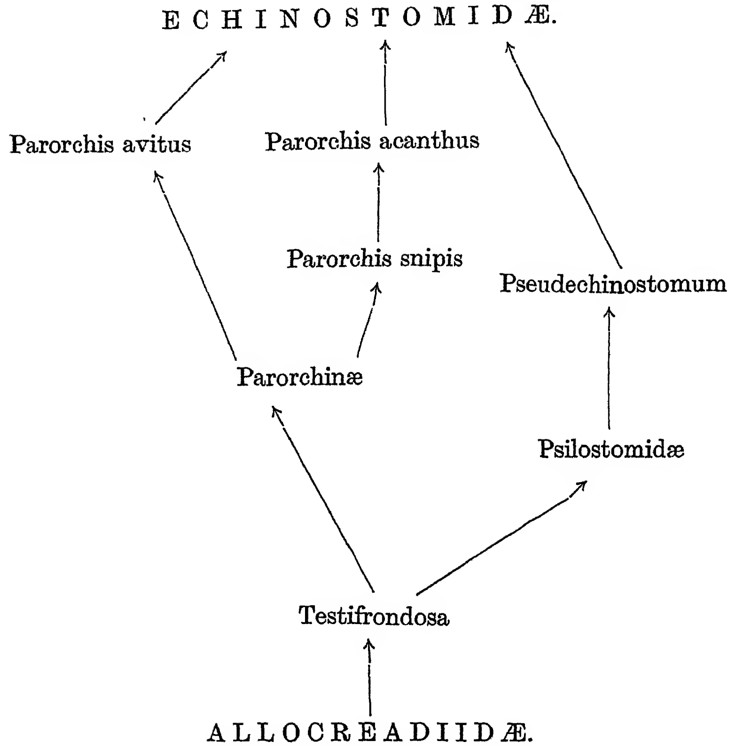
2 Thapar, G. S.—A new genus, *Acanthogyrus* from fish and classification of Acanthocephala. *Journ. Helminth.*, vol. V, 1927.

3 Meyer, A.—Acanthocephalen. *Zool. Jahrb., Syst. Bd.*, 62, 1931.

4 Van Cleave.—New Order in the Acanthocephala. *Journ. Parasit.*, vol. XXII, 1936.

5 Sewell, R. B. S.—Evolution of Excretory system in Furcocercous Cercariæ. *Rec. Ind. Mus.*, vol. XXXII, 1930.

other. The discovery of *Cotylogonoporum* indicated a probable relationship between Allocreadiidæ and Heterophyidæ.[1] A probable course of evolution of Psilostomidæ from Allocreadiidæ was indicated in 1935,[2] and this was further elaborated by Lal [3] for Echinostomidæ thus :—



It is hoped that further investigations on the morphology and connected problems will help to solve the question of relationships of the various families of the helminth parasites.

Life Histories.

While morphology and classification offer a wide scope for work in India, and are likely to influence ideas concerning the

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[1] Thapar and Dayal—New trematode from golden orfe with a note on the classification of Allocreadiidæ. *Journ. Helminth.*, vol. XII, 1934.

[2] Thapar, G. S. and Lal, M. B.—A New genus of Trematodes from kingfisher. *Proc. Ind. Acad. Sci.*, vol. II, 1935.

[3] Lal, M. B.—A New Species of *Parorchis* with remarks on Echinostomidæ. *Proc. Ind. Acad. Sci.*, vol. IV, 1936.

evolution and relationships of the helminth groups, the solution of the life histories will facilitate our work on the control measures. Past work, like that of Leuckart on the guineaworm and of Looss on the hookworm, gives us hope for a successful attack upon the secrets of the wanderings of parasites in a tropical country like India. One cannot help recollecting the monumental work of Leiper on Schistosomiasis in Egypt.[1] By a carefully organized campaign, Leiper obtained results that threw discredit upon the hypothesis of Looss and further threw an entirely new light upon the problem. His discovery of the identity of the life history of *Schistosoma* with that found in other flukes with a snail intermediary suggested an entirely new method for the eradication of the disease. Leiper discovered that it is not the *miracidium* that penetrates through the skin, as held by Looss, but it is the *cercaria* that bores its way through the skin by its own activities. This discovery, coupled with certain observations on the characters of the snail intermediaries, led him to draw conclusions of great importance towards the control of this dreadful disease which has been afflicting Egypt from times immemorial, and further illustrates the rôle of Biology in the service of mankind. Recently, in the course of our observations on the helminth parasites of domestic animals at Lucknow, I have met with a number of *Echinococcus* cysts which showed the development of scolices

(*b*) (*a*)

Fig. 2. Microphotograph of Echinococcus cyst cut open showing (*a*) Capsule, (*b*) Germinal wall with scolices.

directly from the localised patches of the germinal wall, without the usual intervention of the brood capsules commonly described

[1] Leiper, R. T.—Report on the Bilharzia Mission in Egypt. *Journ. Roy. Army Med. Corps.*, vols. XXV–XXX, 1915–1918.

for the parasite in the standard works on zoology. This apparent identity with *coenurus* cyst is interesting. Again, Amphistomes are constantly threatening our livestock in India and the investigations on their life histories will greatly alleviate suffering. Investigations of this kind have to be carried out by the experimental infection of hosts with a view to find out the mode of migration of the larvæ through the tissues prior to their final establishment in the host.

Host Specificity.

Much attention has been paid in recent years to the problem of the host specificity of the parasites. It was long held that a helminth species is restricted to a particular species of host and that its occurrence in other hosts is not likely. Under these conditions the larva, if it entered the body of its host, seldom gets lost, but in the abnormal host it frequently becomes an aimless wanderer and ultimately perishes. There seems to be no somatic acclimatization and the determining factors for host specificity are imperfectly known. At present there seem to be two conflicting views. Fuhrmann [1] and Baer [2] believe in the close relationship of the parasite with its own specific host. There is a high degree of specialization in the relation of the helminth parasites to the hosts and consequently host specificity is limited, at any rate for the Cestodes. Meggitt,[3] however, controverts this view, strange to say, for Cestodes and finds that there is no such limitation to a single group of hosts. Sinha [4] recently brought forward instances amongst the reptilian Trematodes in support of Meggitt's view. The question thus remains open for the Platyhelminthes at any rate and seems to offer interesting scope for further investigations.

Diseased Condition.

The lack of exact knowledge of the relation of the parasite with the host can be illustrated by the case of *Enterobius vermicularis*—the common pinworm of man. It is now over 300 years ago that Fabricius first recorded the presence of this worm in the human appendix, but it was not until Metchnikoff (1901) laid stress on the rôle of this parasite in causing appendicitis that medical men paid attention to such enquiries by zoologists.

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1 Fuhrmann, O.—Les Ténias des oiseaux. *Mem. Univ. Neu-Chatel*, vol. VIII, 1932.

2 Baer, J. G.—L'adaptation des helminthes à leurs hôtes. *Bull. Soc. d. Sci. Nat., Neu-Chatel*, vol. LVIII, 1934.

3 Meggitt, F. J.—Theory of host-specificity as applied to Cestodes. *Ann. Trop. Med. Parasit*, vol. XXVIII, 1934.

4 Sinha, B. B.—Thesis on 'The Trematode Parasites of Reptiles' presented for the degree of D.Sc. of the Lucknow University.

It was long held that the presence of the pinworm in the appendix is in the first place extremely rare and when present could not give rise to ulceration of the wall. Researches by Rheidorf (1920) and more recently by certain Japanese investigators have conclusively proved the importance of the pinworm as a cause of appendicitis, at any rate, by producing ulceration which helps the development of the causal bacteria. Morton and Archer [1] record abdominal cases due to *Ascaris*, simulating acute surgical disease of the abdomen, especially appendicitis, abscess or intestinal obstruction.

Amongst the domestic animals, we have a very interesting case in the disease commonly known as 'Snoring disease' or 'Nasal Granuloma' of cattle. The etiology of this disease has been a baffling problem for many years when it was considered to be due to the characteristic ray-fungus, causing actinomycosis, but experimental evidence in the transmission of the disease to healthy cattle always gave negative results. It was then held to be due to a species of *Rhinosporidium* in the papules of the nose of the cattle and this was considered by Dikmann (1932) in a preliminary note in American cattle showing identical symptoms. About the same time, Datta in India,[2] announced his discovery of the *Schistosoma spindalis* as a cause of this disease and supported it by clinical diagnosis. It was subsequently confirmed by the independent observations of Malkani [3] and other workers in India. Datta [4] also discovered another disease 'Barsati' in equines and found that it is not of mycotic origin as was originally held, but that it is also of helminthic origin, being due to the presence of the larvæ of a nematode worm, *Habronema muscæ*, affecting the internal organs including the lungs. Instances of this nature are multiplying and further investigations may result in the demonstration of other diseases of the animals that are of helminthic origin.

Anthelmintics.

While disease investigation is in progress, it would be desirable to suggest preventive and control measures and this brings us to the very important problem of anthelmintics. Anthelmintics, as we know, are the drugs that are used to kill or expel the worms in the alimentary canal or other organs in the body of the host. There are a large number of these drugs

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1 Morton and Archer.—Ascariasis: Some Surgical and Roentgenologic Aspects. *Journ. Amer. Med. Assn.*, vol. XCVIII, 1932.

2 Datta, S. C. A.—The Etiology of Bovine Nasal Granuloma. *Ind. Journ. Vet. Sci. Anim. Husb.*, vol. II, 1932.

3 Malkani, P. G.—Discovery of the Cause of Nasal Granuloma in Cattle. *U.P. Vet. Mag.*, vols. XXII and XXIII.

4 Datta, S. C. A.—The Etiology of Barsati. *Ind. Jour. Vet. Sci. Anim. Husb.*, vol. III, 1933.

whose action has been emphasized in our indigenous system of medicine. Thus 'Makhzan', a book on Indian medicine, gives a long list of indigenous plants that are used as anthelmintics by Hakims, and Vaids likewise prescribe different plant products, such as the dried leaves, root bark, seeds and fruit juices of a variety of plants for the removal of worms from the body. It is said that each drug is administered for a particular kind of worm, and the efficacy of some of these drugs has been acknowledged even by the Western physicians in India. A careful systematic analysis of these drugs from plant products will be essential to determine the active principle contained for the removal of the worms from the body of the host. Chopra (1928) has summarized the various anthelmintics used by the Hakims and Vaids and has given their analysis in a majority of cases, but there are still a large number that need further investigation. The crude method of administration of certain plant products, like the juices of *Blumea lacera* (kukronda) as local application and otherwise against the common pinworm of man by laymen, offers a fresh field in the study of drug administration in their natural condition, particularly to the domestic animals.

The effects of yeast and vitamins on the incidence of parasitism and immunity problems would naturally form a necessary supplement to this chemotherapy problem and it would be desirable to conduct experiments to obtain parasite resisting strains of animal population that would be better fitted in the struggle for existence. This has opened up an entirely new field for investigation in Parasitology and has already yielded promising results.

Pearl Formation.

In the foregoing remarks, I have indicated the ill effects that the parasites belonging to the helminth groups may cause in the body of animals, but their presence may even demonstrate the utility to man of worm infections in some animals, and here we have the instances of pearl production inside molluscan shells. Though not much work has yet been done on the subject, there is a rich field for the future. Formation of pearls in the fresh water mussel is said to be due to larval worms. Hornell and Herdman pointed out the agency of larval *Tetrarhynchus* in the formation of pearls in Ceylon oysters and in order to increase pearl yield in oyster beds the growth of these larvæ was encouraged. Southwell[1] found *Tylocephalum* an important agent in the production of pearls in oyster, while Hopkins considers the presence of encysted cercariæ of *Allocreadium*

[1] Southwell, T.—Helminthology in its applications to marine fisheries. *Journ. Helminth.*, vol. XI, 1933.

ictaluri in Unionidæ to be a good presumptive factor to induce pearl formation in fresh water clams.

Need of Co-operation.

These are some of the opportunities for research which the study of helminthology in India offers. There is a growing appreciation of the importance of helminths as a cause of diseases in domestic animals. But although the departments of medicine, public health, agriculture and veterinary science have all been doing useful work in their respective spheres, they all stand unconnected. The problems facing helminthologists require for their solution the help of specialists in several other departments, in particular the medical and veterinary departments. Far-reaching success may be expected from co-operative work in India on an intensive scheme dealing with some of the principal problems of helminthology. We have a notable example before us in the success achieved recently by a group of investigators working on hookworm under the leadership of Dr. Cort of the Johns Hopkins University. In the United States of America, co-operation exists in the Bureau of Animal Industry where teamwork has yielded results of immense value in the control of animal disease. In his constructive administrative scheme on the *Bilharzia* mission in Egypt, Leiper suggested the employment of a trained zoologist in the Irrigation department; and emphasized the necessity of such a co-operation between various departments of a country. With a close network of canals in India, the intermediate hosts of a large number of helminths are carried about from place to place and the transmission of the infection is, therefore, facilitated. The useful results of co-operation became apparent when recently the skin disease of the cattle, commonly known as 'Cascado' in the Dutch East Indies was re-investigated and it was discovered by zoologists that the disease was due to a nematode parasite, *Stephanofilaria*, and not to 'mange mite' as was originally supposed. The need for co-operation was even emphasized a few years ago by the Royal Commission on Agriculture in India presided over by our present Viceroy, and on looking over the progress made in other countries, one cannot but be impressed with the desirability of taking such a line of action.

Ladies and Gentlemen, in placing these observations before you, I have relied mainly on my own experience in this branch of the subject and have cited instances that have come directly or indirectly under my observation. The views expressed may not be entirely in conformity with those of other workers, but it is hoped that they may rouse interest in the study of helminthology in the country. By patient interest and diligent application on the varied problems, we can help in the solution of the problems connected with helminthological research, and

establish an active school of helminthology in India. I would consider my object well served, if I have succeeded in my attempt to stimulate an interest for investigations in this important field of activity.

SECTION OF ZOOLOGY

Abstracts

1. On a species of *Isospora* from the intestine of *Naja naja* Linn.

A. N. MITRA *and* M. DAS-GUPTA, Calcutta.

Oocysts of *Isospora* were found in the faecal matter of a male cobra, *Naja naja*, in July 1935. After being kept in 1% Chromic acid for three days disporocystid condition of the oocyst was evidenced. In this respect it differs from *I. dirunpens* Hoare in which spores become mature in the wall of the intestine (intra and sub-epithelial region). Maximum size of oocyst is $15\mu \times 7{\cdot}5\mu$. Sporocysts circular and measure $7{\cdot}5\mu$ in diameter. Oocystic residuum is absent, and thus differs from *I. naiæ* Fantham. We propose to call it *Isospora minuta* n.sp.

2. On a species of *Eimeria* (Coccidia-Sporozoa) from the intestine of a pigeon, *Columba intermedia.*

A. N. MITRA *and* M. DAS-GUPTA, Calcutta.

Coccidian oocysts were met with in the gut contents of a pigeon, *Columba intermedia* in March 1935. When kept in 1% Chromic acid for four days. tetrasporocystid dizoic conditions of the oocyst were observed. The maximum size of the oocyst is $16{\cdot}4\mu \times 14{\cdot}35\mu$ and oocystic residuum is present and thus it differs from *Eimeria pfeiffer* (Labbe, 1896). Oocysts are sub-spherical and thus differ from *E. avium.* The complete life history has been worked out. We propose to call it *Eimeria columbæ* n.sp.

3. Observations on *Nina navillæ* n.sp. from *Scolopendra* sp.

A. N. MITRA *and* M. CHAKRAVARTY, Calcutta.

Sporonts solitary and measure 819–975μ in length and 97–190μ in breadth. In sections, intracellular stages could not be found which suggests their extra-cellular mode of development. Gametocysts, oval, measuring $125\text{–}175\mu \times 95\text{–}125\mu$. Spores spherical to oval, with two envelopes and liberated in chains.

4. On *Adelina schellacki* n.sp., from the intestine of a Centipede, *Cormocephalus dentipes* Poc.

H. N. RAY *and* M. DAS-GUPTA, Calcutta.

Life-history of *Adelina schellacki* n.sp. has been described in detail. Oocyst oval or egg-shaped measures $35\mu \times 20\mu$. There is no residue. Eight spherical sporoblasts with two sporozoites in each are formed within 10–15 days if the unsegmented oocysts are kept in moist chamber. If kept in 1% Chromic acid solution, oocysts degenerate within a very short time. The common investment membrane ruptures after being in the moist chamber for 4-5 days and along with this the unused microgametes are discarded.

5. On a new *Coccidium* from the intestine of *Python* sp.

H. N. Ray *and* M. Das-Gupta, Calcutta.

Oocysts measure 25–30μ in diameter. Eight primary sporoblasts are formed. After sometime these eight sporoblasts divide to form sixteen which ultimately are converted into sporocysts each containing four sporozoites and a central residue. Male gametes are formed as in Eimeriidæ. Female gametes are often seen lying in the submucosa. Segmented or unsegmented oocysts are to be seen in the faecal matter and when kept in 1% Chromic acid solution mature within 7–10 days. Segmenting oocysts were also seen in the epithelium. Spores measure 8–10μ in length and 6-7μ in breadth.

Tetrazoic Leccdeceasporcystid condition of the oocysts at once marks this coccidium out from any known Coccidia. We propose to call it *Pythonella bengalensis* n.gen., n.sp.

6. The life-history of a Dicystid-Gregarine, *Lecudina* sp. from the gut of *Lumbriconereis* sp.

P. N. Ganapathy *and* R. Gopala Aiyar, Madras.

The paper deals with a detailed study of the morphology and life-history of the Gregarine occurring in the gut of a polychæte belonging to the genus *Lumbriconereis*, probably a new species. The earlier stages are found in an intra-cellular condition within the gut-epithelium. After a certain amount of growth, which is detrimental to the host-cell, the parasite drops down into the gut-lumen. Attachment to the gut-epithelium is effected by means of a well-developed epimerite, which is endoplasmic in origin, functioning as a sort of sucker and organ of attachment. Epimerite is completely extra-cellular.

Association takes place between two mature trophozoites and the gametocyst is formed. By repeated nuclear divisions within the gametocytes, a number of gamete nuclei are formed which are anisogamous. When the gametes are fully developed, the partition wall between the gametocytes breaks down and conjugation takes place between two different gametes. As a result the zygote is formed and the cysts at this stage are passed outside the host along with its castings, and the further stages in sporogony take place in the natural medium in which the worms live. The sporocysts are rounded in outline with a thickening of the spore-wall at one pole. There are eight sporozoites inside each spore.

A discussion follows about the significance of the various stages in the life-history and the relationships of this parasite.

7. Studies of *Peachia* from Madras.

N. Kesava Panikkar, Madras.

Medusophilous larval stages and sand-burrowing adults of the Athenarian anemone, *Peachia* (Family Ilyanthidæ) are recorded for the first time from the Madras coast. The structure of the adult and the developmental stages of the epizoic larvæ are described in detail. The column of the Actinian is long and vermiform and does not show differentiation into distinct regions. There are sixteen tentacles which are dicyclic in arrangement, those belonging to the exocoels being larger than others. The conchula is prominent and five-lobed. The mesenteries are sixteen in number; they are arranged in two cycles without any distinction into macrocnemes and microcnemes; and all of them are fertile and have well developed retractors. The primary cycle is constituted of the first six pairs, while the remaining two pairs found in the lateral exocoels of the primaries, belong to an incompletely developed secondary cycle.

The anemone is referred to a new species, *Peachia tropica*, as the arrangement of tentacles and the nature of the mesenteries, especially the development of gonads and filaments in those belonging to the secondary cycle, are characteristic features not known in other species. The probable order of succession of mesenteries and tentacles and the systematic relationships of the anemone are discussed.

The medusophilous larvæ are found attached to the sub-umbrellar surface of *Aequorea pensile* (Modeer), a common Hydromedusa of the Madras plankton. Very young larvæ are disc-shaped, but older individuals are conical and become fairly elongated by the time they are about to drop down from the jelly-fish. The conchula and tentacles appear comparatively late in the course of development. The development of the conchula, actinopharynx, and mesenteries is described. The part played by the oesophageal lobes and conchula during larval life is discussed and the homology of the conchula elucidated.

8. Observations on *Arachnactis* of the Madras plankton, together with a general account of the Anthozoan larvæ of the Madras Coast.

N. Kesava Panikkar, Madras.

(*Communicated by Prof. R. Gopala Aiyar, Madras.*)

The anatomy, histology and developmental stages of the epiplanktonic larval Cerianthid, *Arachnactis*, collected from the Madras coast, are described. The marginal tentacles excepting the directive, appear very early in development and in young stages the body proper of the larva is insignificant as compared to the tentacles. The directive tentacle develops during the 8-9 tentacle stage and remains small even in older individuals with numerous marginal as well as labial tentacles. The second protomesenteries are shorter than the first set of metamesenteries and have filaments with ciliated tracts; the orthocraspedon belongs to type I of Carlgren. The first metamesenteries are the longest in the larva; and each mesentery belonging to this couple carries a single slender acontium at its aboral extremity. The relationships of the larva with other known forms of *Arachnactis*, and the distribution of the different species are discussed.

A systematic account of the Anthozoan larvæ of the Madras coast is given along with the periods of their occurrence in the plankton; and some observations are made on *Anactinia pelagica* Annandale among the Ceriantharia, and on the different kinds of Semper's larvæ, belonging to the larval genera *Zoanthina* and *Zoanthella* among the Zoantharia.

9. A new Trematode from the intestine of a fish, *Clarias magur*.

J. Dayal, Lucknow.

A large number of monostomes are known but the present form differs from them in the position of the testes, the ovary, the genital opening, etc. However, the nearest ally of this form is the genus *Tamerlania* from which it differs in the relative position of the testes, vitelline glands and the position of the genital opening. These necessitate the creation of a new genus for the form under review.

In the paper the author discusses the relationship of the present form with other known genera of monostomes and finds the necessity of the creation of a new family, allied to Eucotylidæ, for the form under review.

10. Observations on the sexual congress in *Levinseniella indica*.

M. B. Lal, Lucknow.

Specimens of this trematode were recovered in copula from the bursa fabricii of the Jack snipe, *Gallinago gallinula*, at Lucknow. Copulation was observed under the low power of microscope. The paper describes the observations in detail and compares them with similar observations on other forms by previous workers.

11. On the characters of systematic importance in the classification of Trematodes.

M. B. Lal, Lucknow.

The classification of trematodes has been based on different morphological characters by various authors, but these present certain defects. The writer, in the course of his investigations on the trematodes of birds, has come across certain important features that necessitated the revision of the classification of this group. The relative merits of different characters are discussed in the paper and conclusions arrived at to show that only those morphological characters should be considered of primary importance as are of constant occurrence both in the adults as well as the larval forms. Importance of characters other than these is also indicated in the course of discussion.

12. New Fellodistomids (Trematoda) from Indian fishes. Part II—Two new parasites of the sub-family Discogasterinæ Yamaguti, 1934, from Indian marine food fishes.

H. D. Srivastava, Muktesar.

Yamaguti in 1934 created two new genera—*Discogaster* and *Paradiscogaster* for parasites obtained from the gut of Japanese marine fishes. The author adds two more trematodes to the subfamily collected from the intestine of Indian fishes. *Discogaster lateroporus*, n.sp., occupies an intermediate position between the two have mentioned Japanese genera in some of its characters. It differs from *D. ostracionis* in the length of oesophagus, much smaller size of acetabulum, position of gonads, extent and position of vitellaria. In the character of its cirrus sac and position of genital pore it is markedly different from the Japanese forms of the subfamily. *D. yamaguti*, n.sp., resembles the type species in the length of oesophagus and the relative position of gonads but differs from all the Japanese forms in having short, saccular, horizontal cæca, small, spindle-shaped cirrus, peculiar shape of oesophagus, smaller size of acetabulum and the disposition of vitellaria which lie in a horizontal line between oral sucker and intestinal cæca. The validity of *Paradiscogaster* is discussed and the genus is dropped as synonymous with *Discogaster*. A key to the species and an amended diagnosis of the genus are given.

13. New Fellodistomids (Trematoda) from Indian food fishes. Part III—A new parasite of the genus *Haplocladus* Odhner, 1911, from the gut of an Indian marine fish.

H. D. Srivastava, Muktesar.

Amongst the digenetic trematodes, the genus *Haplocladus* is unique in having a single intestinal cæcum which opens to the outside at the posterior end. So far only two species of the genus are known. In this

paper the author gives an account of the third species *H. orientalis*, n.sp., obtained from the gut of a marine fish at Puri. In its general organization the Indian form resembles the type species—*H. typicus* Odhner, but it differs from the latter in the size ratio of suckers, size of the various organs, extent and character of vitellaria and the topography of gonads. A key to the species of the genus is given.

14. New Fellodistomids (Trematoda) from Indian food fishes. Part IV—On a new genus *Yamagutia* gen. nov., from the intestine of an Indian marine fish.

H. D. SRIVASTAVA, Muktesar.

The paper embodies an account of the morphology and systematic relationships of an interesting distome which is provisionally assigned to the family Fellodistomidæ. Body medium-sized, elongated with bluntly pointed ends. Suckers muscular, spherical; oral sucker subterminal; acetabulum post-equatorial. Prepharynx, pharynx and oesophagus present; cæca narrow, straight, stopping a little in front of hinder end. Gonads equatorial. Testes two, oval, nearly symmetrical, pre-acetabular; vesicula seminalis, pars prostatics and prostate glands well developed. Ovary pretesticular, sinistral. Vitellaria in two lateral, mostly extracæcal, rows extending from level of ovary to a little beyond the level of acetabulum. Uterus occupies the whole of post-acetabular region running terminally into a very characteristic metraterm; eggs numerous, operculate. Genital pore about the middle of pre-acetabular region. Excretory bladder U-shaped, cornua extracæcal, reaching up to the level of pharynx.

The characteristic features of the new genus are the preacetabular position of gonads, position and extent of vitellaria, characteristic structure of the terminal part of genital ducts, U-shaped excretory bladder. The systematic position of the genus is discussed in detail.

15. New Hemiurids (Trematoda) from Indian marine food fishes. Part II—Three new parasites of the genus *Sterrhurus* Looss, 1907.

H. D. SRIVASTAVA, Muktesar.

The morphology, anatomy and relationships of three parasites of the genus *Sterrhurus* obtained from the stomach of two marine and one migratory fish have been studied. *S. monolecithus* n.sp., is a common parasite in the stomach of *Clupea ilisha* at Allahabad and Puri. The main characteristic features of this species are the presence of an extremely rudimentary tail, hardly visible in some specimens and a single large compact vitelline mass. *S. karachii* n.sp., resembles *S. monolecithus* in most of its features but differs mainly in the relatively smaller size of body, and in having a pair of compact, elongated oval vitelline follicles. In its affinities *S. sihamai* n.sp., stands nearest to *S. inimici* but differs from the latter in comparatively much smaller length of its tail, besides differences in the size and positions of its various organs. A key to the species and an amended diagnosis of the genus are included.

16. New Hemiurids (Trematoda) from Indian marine food fishes. Part III—Two new parasites of the genus *Lecithocladium* Looss from Indian fishes with a revision of the genus.

H. D. SRIVASTAVA, Muktesar.

In this paper are described two new species of *Lecithocladium*—*L. brevicauda* and *L. harpodoni* n.spp., parasitic in the stomach of two marine

fishes from the Bay of Bengal. The former species is of rarer occurrence than the latter. It shows unmistakable affinities with *L. excisiforme* Cohn but differs from the latter mainly in the relative length of the tail, size of suckers and the posterior extent of uterus which does not extend into the tail. *L. harpodoni* differs from the above species in the topography of gonads, size ratio and position of suckers and the configuration of uterine coils, besides differences in the size of the various organs. A brief resumé of the work on the genus and a discussion on the validity of the various species included under the genus are given.

17. New Hemiurids (Trematoda) from Indian marine food fishes. Part IV—On a new species of trematode, *Ectenurus indicus* n.sp., from the gut of several marine fishes.

H. D. SRIVASTAVA, Muktesar.

The genus *Ectenurus* was created by Looss in 1907 and since then a number of species have been added to it, some of which do not really belong to this genus. The species described in this paper is the commonest trematode infecting Indian marine fishes. Of all the valid species the Indian form comes nearest to *E. hamati* Yamaguti, 1934, specially in respect of its peculiar terminal part of the genital ducts. The important points of specific difference lie in the length of tail, position of testes, disposition and character of vitellaria and the posterior extent of uterine coils. The validity of the different species under the genus is discussed.

18. New Hemiurids (Trematoda) from Indian marine food fishes. Part V—A new parasite *Stomachicola secundus* n.sp., of the sub-family Dinurinæ.

H. D. SRIVASTAVA, Muktesar.

The first representative of the sub-family Dinurinæ in an Indian host was discovered by the author in the stomach of *Clupea ilisha* and published in 1935. *Stomachicola secundus* is the largest distome 23 to 35 mm. so far collected from Indian fishes. Though it differs from the type species, *S. murænesocis*, in most of its features, it is assigned to the genus *Stomachicola* Yamaguti, 1934, whose diagnosis is modified to accommodate it. The parasite is slightly smaller than the Japanese species in length but in breadth it is about twice as broad. It differs from the type species in the relative positions of suckers, obliquely tandem position of testes, posterior extent of vesicula seminalis which does not extend beyond acetabulum, peculiarly tetra-lobed mushroom-shaped ovary, extent of vitellaria and position of genital pore.

19. New Hemiurids (Trematoda) from Indian marine food fishes. Part VI—Two new parasites of the genus *Aponurus* Looss 1907, (sub-family—Lecithasterinæ).

H. D. SRIVASTAVA, Muktesar.

About half a dozen valid species of *Aponurus* are known from the gut of American, European and Japanese fishes. In this paper are described two new species, *A. breviformis* and *A. bengalensis*, from two fishes from the Bay of Bengal. The former is the minutest trematode collected from Indian fishes. It differs from *A. rhinoplagusiæ* Yamaguti, 1934, which it resembles closely, in the size of body, size ratio of suckers, posterior extent of vesicula seminalis, position of genital pore, size of receptaculum seminis and the length of cæca.

A. bengalensis is remarkably different from the above two species in the shape of body, length of pars prostatica, size of vesicula seminalis and position of testes. A modified diagnosis and a key to the species of the genus are included.

20. New Hemiurids (Trematoda) from Indian marine food fishes. Part VII—A new parasite of the genus *Hysterolecitha* Linton, 1910.

H. D. SRIVASTAVA, Muktesar.

Linton in 1910 created the genus *Hysterolecitha* for a trematode which he obtained from an American fish. Subsequently three more species, one American, one Russian and one Japanese, have been added. In this paper is described the fifth species of the genus—*H. lintoni*—from the intestine of an Indian marine fish. The Indian representative differs from the other members of the genus in a number of features, important amongst which are the position of gonads, size of suckers, position of genital pore. The validity of all the species is discussed and a key to their identification is given.

21. New Hemiurids (Trematoda) from Indian marine food fishes. Part VIII—The morphology and systematic relationship of a new parasite, *Indoderogenes purii*, gen., et sp. nov., (sub-family Derogenetinæ).

H. D. SRIVASTAVA, Muktesar.

The account of seven representatives of the sub-family Derogenetinæ in Indian hosts was published by the author in 1933. In this paper is given an account of yet another member, *Indoderogenes purii*, of the sub-family from the gut of a marine fish examined at Puri. Body smooth, medium-sized, cylindrical with bluntly pointed ends. Suckers spherical, muscular; acetabulum larger than oral sucker, situated close behind intestinal bifurcation. Prepharynx and oesophagus absent; pharynx present; cæca stop in front of ovary. Testes two, spherical, nearly equatorial, obliquely tandem. Vesicula seminalis bulb-shaped, pars prostatica small surrounded by prostate glands, ductus hermaphroditicus opening on a conical papilla in the genital atrium close behind oral sucker. Ovary pear-shaped. Vitellaria in two compact partly overlapping masses. Mehlis gland to the left of ovary. Ovary, vitellaria and Mehlis gland all crowded into the hindermost part of body. Uterus preovarial, mostly intercæcal, eggs numerous. Excretory bladder Y-shaped with cornua uniting dorsal to oral sucker. The characteristic features of the new genus are the relative position of suckers, topography of gonads, and the crowding together of ovary, vitellaria and Mehlis gland in the posterior tip of body. The present scope of the sub family and the relationships of the various genera are discussed.

22. The parasites of the family Acanthocolpidæ Luhe, 1909, from Indian marine food fishes.

H. D. SRIVASTAVA, Muktesar.

In this paper is included an account of two new parasites of the family Acanthocolpidæ obtained from the gut of certain fishes from the Bay of Bengal and the Arabian Sea.

Stephanochasmus indicus n.sp., described from the intestine of *Pristis cuspidatus* differs from *S. japonicus*, which it resembles closely, in the number and arrangement of oral spines, anterior extent of vitellaria, position of gonads and the posterior extent of cirrus sac.

The second distome described in the paper is *Echinostephanus cloacum* n.sp., parasitic in the gut of *Hemirhamphus far*. The genus *Echinostephenus* was established by Yamaguti in 1934 for an interesting parasite from a Japanese marine fish. The genus, which contains only one species so far, is unique amongst the members of the family Acanthocolpidæ in the character of its spines, in its intestinal communication with the excretory bladder and excessive length of cirrus sac. The Indian species differs from the type species, *E. hispidus*, in the number and arrangement of oral spines, size ratio of suckers, position of testes and the length of

23. New Allocreadiids (Trematoda) from Indian marine food fishes. Part III—*Pedunculacetabulum pedicellata* n. sp., from the gut of *Chiloscyllium indicum*.

H. D. SRIVASTAVA, Muktesar.

The genus *Pedunculacetabulum* was created by Yamaguti in 1934 for an interesting Allocreadiid parasite in the gut of three different species of Japanese marine fishes. The feature which distinguishes this genus from other genera of the family Allocreadiidæ is the possession of a small acetabulum situated on a long pedicle. During an extensive parasitological examination of marine fishes the author came across two mature specimens of the above genus. The Indian form which is described as a new species resembles the type species, *P. opisthorchis*, in the character of acetabulum and cirrus sac. It differs from the type species in the shape of pedicle, lateral position of genital pore, far forward position of testes from the posterior end, position of receptaculum seminis and extent of vitellaria.

24. A new Gorgoderid Trematode from the urinary bladder of an Indian migratory fish—*Belone strogylura*.

H. D. SRIVASTAVA, Muktesar.

In this paper the author gives an account of the first representative —*Phyllodistomum lewisi* n.sp.—of the family Gorgoderidæ Looss, 1902, in Indian hosts. The genus *Phyllodistomum* was created by Braun in 1899 and since then a large number of species have been added. Recently Lewis, in whose honour this species is named, published a masterly revision of the genus and has given a key to its valid species. In its affinities *P. lewisi* n.sp., falls in the group of species with a spatulate body, i.e., posterior portion sharply marked off from the neck, with preovarian vitellaria and intercæcal uterus. However, the points of specific difference are the size ratio of suckers, relative length of the neck and spatulate portion, character of vitellaria and the presence of marginal, semilunar, feebly muscular adhesive structures on either side of the spatulate portion of the body.

25. Studies on the Gasterostomatous Trematodes of Indian food fishes.

H. D. SRIVASTAVA, Muktesar.

The first report of the occurrence of Gasterostomes was published by the author in 1933 and a second in 1935. In this paper the author embodies the account of ten different species of Gasterstomes referable to the genera *Bucephalus, Bucephalopsis* and *Prosorhynchus*. *Bucephalus indicus* and *B. gangeticus* spp.n., were obtained from the gut of *Macrones seenghala* and *Pseudotropius athenoides* respectively, while *B. barina* n.sp., was found parasitic in the gut of several fishes of the Bay of Bengal.

Prosorhynchus manteri n.sp., is a common parasite of the gut of *Tetradon oblongus* at Puri while *P. arabiana*, n.sp., was obtained from the gut of *Synaptura pan* of the Arabian Sea examined at Karachi. An extensive examination of a large number of specimens of the common fresh-water fishes at Allahabad during the year 1933 and 1934 revealed a fairly frequent infection with two species of *Bucephalopsis* which have since been described by Varma, 1936, as *B. garnai* and *B. fusiformis*. A seasonal fish in the Ganges and Jumna at Allahabad was found harbouring in its gut specimens of *Bucephalopsis belonea* n.sp. Immature specimens of *Prosorhynchus crucibulum* (Rud.) Odhner, 1905, were obtained from the intestine of a marine fish at Karachi. The relationships of the Indian forms with those of other countries are discussed and an identification key is given.

26. Studies on the amphistomatous parasites of Indian food fishes. Part II—New parasites of the genus *Gyliauchen* Nicoll from the intestine of an Indian marine fish.

H. D. Srivastava, Muktesar.

Ozaki in 1933 established the family Gyliauchenidæ which now includes three genera: *Gyliauchen* Nicoll, 1915, *Telotrema* Ozaki, 1933, and *Paragyliauchen* Yamaguti, 1934. The last two genera are so far represented by only one species each, while the type genus has two species, *G. taurachodes* Nicoll, 1915, and *G. papillatus* Goto and Matsudaira, 1918. A large number of specimens which on subsequent study have proved to represent a new species of the type genus *G. ozakii*, n.sp., were collected from the intestine of *Harpodon nehereus*. The Indian form differs from the two hitherto known species of the genus in a number of characters important amongst which are the size and shape of body, topography of gonads and the length and course of oesophagus.

27. On the systematic position of the genus *Xenopharynx* Nicoll.

B. B. Sinha, Lucknow.

The systematic position of the genus has been a matter of much controversy; it being assigned a position by the original author, under the family Dicrocœliidæ. Subsequently, on account of some amendment in the generic diagnosis, it was transferred to the sub-family Telorchiinæ, and again back to the family Dicrocœliidæ. The author finds that in the light of our present knowledge of Trematoda, its position under either of the above two groups is untenable. He has, therefore, advocated a view for its inclusion in the family Plagiorchidæ with the members of which it shows very close morphological relationship.

28. *Dirofilaria indica* n.sp., from dog.

G. K. Chakravarty, Calcutta.

In this paper has been described a new species of the nematode genus *Dirofilaria* obtained from the heart of a dog. Affinities of this new worm have also been discussed.

29. Preliminary observations on the swarming habits and lunar periodicity of *Platynereis* sp. from Madras Harbour.

R. Gopala Aiyar *and* N. Kesava Panikkar, Madras.

While making night collections of specimens from the Madras Harbour, swarming of Heteronereids of *Platynereis* sp. was observed on a few

occasions. The worms dart through the water with lightning rapidity, in a spiral manner, leaving a trail of phosphorescence which is actually caused by countless swarms of *Noctiluca*. Swarming starts at about 7-30 P.M. and usually lasts for about an hour and a half and on every occasion when the phenomenon was noticed, the sea was calm and there was brilliant phosphorescence. After a time, only stray individuals were met with. Several dead specimens were found floating the next morning. There is every reason to believe that after the extrusion of the genital products, the worms die. The Polychæte in question does not appear to belong to *Platynereis dumerilii*, *P. polyscalma* or *P. megalops*. Specimens of both sexes have been obtained, but the males were more numerous than the females. The epitokous region is empty in worms collected after swarming. The body musculature is highly reduced. The walls of the alimentary canal have begun to degenerate. In the body cavity of the males, only traces of spermatozoa could be found.

Regular observations show that the display starts a day prior to the New Moon and is repeated on the two succeeding days at the same time, though with less intensity. A comparison with other swarming Polychætes is made and the question of lunar periodicity in reproduction is discussed.

30. The anatomy of *Glyphidrilus annandalei* Mich.

K. Bhaskaran Nair, Madras.

The anatomy of *Glyphidrilus annandalei* has been worked out. The following are the more important features. There is a well-developed supra-œsophageal vessel and a pair of sub-œsophageals. Of the four pairs of hearts the first two arise from the dorsal vessel, while the third and the fourth have a double origin, being formed by roots from the dorsal and supra-œsophageal vessels. The œsophageal and intestinal blood spaces are discontinuous in the fourteenth segment and dissimilar in their structure. The former shows the characteristics of a regular plexus, while the latter is a true sinus. The sub-neural vessel is very poorly developed in the hinder regions and considerably displaced and modified anteriorly. The posterior end of the worm is modified for respiration in adaptation to its semi-aquatic habitat. In the alimentary canal there is a well-developed gizzard in the 8th segment and a very efficient and histologically peculiar straining apparatus in the fourteenth segment. The chromophil cells are not confined to spongy masses over the pharynx, but occur also as isolated bunches attached to the gut near the septal junctions. Excretory system consists only of meganephridia, which make their first appearance in segment 12 or 13. Spermathecæ are numerous, numbering about forty, arranged in four rows in segments fourteen to seventeen. A receptaculum ovorum is present. No spermiducal gland has been noticed. The cocoons are long and spindle-shaped, with a leathery case containing seven eggs on an average. The detailed structure of the wings and tubercles also are described.

31. Economic aspect of insect parasitism.

T. V. R. Ayyar, Coimbatore.

In this paper an attempt is made to present a brief account of the writer's studies on insect parasitism and to point out the economic aspect of this phenomenon with special reference to South Indian conditions. The studies were mainly devoted to the bionomics of the most important and numerous of parasitic insects viz., *Hymenoptera* in their different aspects, particularly their relations to insect pests of cultivated plants and the possibilities of artificially utilising these parasites as natural enemies of plant pests—a popular method known as biological control.

During the course of the study it was also found possible to note numerous new forms of these interesting insects and supplement considerably our limited knowledge of the systematics and bionomics of these very interesting parasites.

32. Recent records of spring tails (*Collembola*) from S. India.

T. V. R. Ayyar, Coimbatore.

Since 1929 when Handrschin published his paper on a collection of Indian Collembola, we have no records of these insects from South India. The author has recently collected a few of these and two of them appear to be new records for the province viz., *Isotoma minos*, and *Xenylla humicola* T. Available information on the bionomics and an up to date catalogue of all South Indian Collembola are added, with the idea that it may be useful for future workers on this little known group.

33. New and known Indian Thysanoptera.

T. V. R. Ayyar *and* V. Margabandhu, Coimbatore.

This is a continuation of a series of systematic papers on *Indian Thysanoptera* previously published either by the senior author or jointly by both the authors since 1928. In the present paper about forty species are noted of which thirty appear to be new species, four new genera and about half a dozen genera not previously recorded from India. These latter are *Podothrips, Stentothrips, Dorcadothrips, Dendrothripiella, Oxyrhinothrips* and *Euphysothrips.* Over half a dozen new species each of *Thrips* and *Tœmiothrips* are also included. Short bionomical notes are also added under each. The idea of the paper is to bring our knowledge of Indian Thysanoptera as far as possible up to date.

34. Biological control in the lac industry.

P. M. Glover, Ranchi.

The lac crops are damaged by two main types of insect enemies, parasites and predators. The damage done by the former is small amounting to an average of only 4·8% of the lac cells. Predator damage is caused almost entirely by the larvæ of the moths *Eublemma amabilis* and *Holcocera pulverea* and amounts to about 35% of the lac cells.

Biological control of lac parasites is not practicable, hyperparasites occur but the average percentage hyperparasitism amounts to only 3·6%. The hyperparasite insects are also in the main primary parasites of *T. lacca.* This, however, is not a serious bar to biological control as the parasites are only minor enemies of lac.

A number of parasites of *E. amabilis* and *H. pulverea* have been obtained and are listed and their function described. Among them, four show special promise. *Pristomerus testaceicollis* and *Apanteles tacharidœ* both important parasites of *H. pulverea* are indigenous in India. *Microbracon greeni* also indigenous in India is parasitic on *E. amabilis,* it can be easily bred artificially, and results indicate that periodical release of laboratory bred adults would be beneficial. The fourth species *Microbracon hebetor* parasite on both *E. amabilis* and *H. pulverea* introduced into India from Ceylon is showing particular promise. Experiments with this species are described.

Although biological control is definitely within the bounds of possibility, it is important that the artificial controls recommended by the Indian Lac Research Institute should not be neglected.

35. Anatomy of the larval stages of *Bruchus quadrimaculatus* Fabr.

D. MUKERJI, Calcutta.

This paper is a continuation of the series in our studies on the pulse beetles and deals with larval anatomy with special reference to the mode of development and method of emergence and boring habit. There are four larval stages separated by moults, and are marked off from each other by the morphological peculiarities. The first two stages closely resemble each other. Their head region is peculiar inasmuch as the brain is not enclosed by the capsule and is posteriorly situated. The head capsule is dorsally covered by a shield which ruptures the egg-shell and is not fixed against the egg-shell as assumed by previous authors. The larva emerges out of the egg-shell by elongation and dorsal flexture of the body. The larva cuts its way into the seed and considerable changes of form take place during boring into the seed. Mesenteron is lined by cells derived from yolk cells. Malpighian tubules are six in number. The ventral nerve cord is composed of thirteen ganglia. In the last two stages the head capsule recedes and encloses the brain. The head shield and the rudimentary legs are lost. Alimentary canal becomes capacious. The last two stages are marked off from the preceding ones by their mouth-parts, by nature of malpighian tubules and by the possession of tracheal dialations.

36. On the salivary glands in the order Coleoptera. Part I—The salivary glands in the family Tenebrionidæ.

R. L. GUPTA, Lucknow.

The present paper is a part of the bigger work in hand, namely, the morphology of the salivary glands in the order Coleoptera. Salivary glands have been very little investigated in the order Coleoptera and are known to exist only in *Anophthalmus* (Carbidæ), *Blaps* (Tenebrionidæ), and *Pyrochroa coccinea* (Pyrochroidæ). In addition to these, unicellular glands in the wall of the foregut of many lamellicorn beetles are also believed to be salivary in function.

As a result of my investigations I have found salivary glands in all the available species of Tenebrionidæ and this leads me to think that probably they are present throughout the family.

The salivary glands in this family consist of a pair of simple tubular glands, as described by Dufour in *Pyrochroa coccinea*, lying coiled in the prothorax and opening in the extra-oral cavity separately on the two sides, unlike the case in *Pyrochroa coccinea* where they unite to form one narrow neck before opening into the mouth. The long simple tubular glands having a central chitinous duct, surrounded by a single layer of glandular cells, coupled with the fact that there are two separate openings, suggest that they are more primitive than those which have a single opening of the common salivary duct, no doubt a result of the secondary union of a pair of invaginations.

37. On the salivary glands in the order Coleoptera. Part II—The salivary glands in the families Coccinellidæ, Curculionidæ and Cerambycidæ.

R. L. GUPTA, Lucknow.

My investigations have proved the existence of simple tubular salivary glands in the families Coccinellidæ, Curculionidæ and Cerambycidæ similar to those described in Tenebrionidæ. The American workers on the alimentary canals of Coccinellids make no mention of salivary glands. But I have found them in all the available species of coccinellidæ.

Structurally the salivary glands in these three families as well as in Tenebrionidæ, are all alike, but they are very long and extensively coiled in Curuculionidæ. In Cerambycidæ the salivary glands are very fine and do not come out of the head but remain coiled near the muscles of the mandibles. As the glands have been found in all the available species it is probable that they are of universal occurrence in these three families.

38. The alimentary canal of *Epilachna indica* (Coccinellidæ: Coleoptera) with a discussion on the activities of the mid-gut epithelium.

S. PRADHAN, Lucknow.

The paper embodies a detailed study of the anatomy and histology of the alimentary canal of *E. indica,* which show the following important differences from those of the only other described species *E. corrupta* investigated by two American workers, Potts (1927) and Burgess (1932): (1) The teeth inside the oesophagus which have been observed by Potts but denied by Burgess are absent in *E. indica.* (2) The structure of the crop in *E. indica* is much more elaborate than in *E. corrupta.* (3) The girdle secreting the peritrophic membrane which has not been described in *E. corrupta* is present in *E. indica.* (4) The so-called 'pyloric valve' which in *E. corrupta* does not occur according to Potts and is very well developed according to Burgess is moderately developed in *E. indica.* (5) The presence and movement of solid excretory material within the malpighian tubules which have been very rarely described in adult insects have been observed in *E. indica.* (6) The presence of the salivary glands has been described for the first time in the family Coccinellidæ.

The paper also includes a morphological study of the activities of the mid-gut epithelium. The contents of the epithelium enter the lumen of the gut as (1) non-nucleated vesicles, (2) individual cells squeezed out in their entirety, (3) delaminations of the portions of the gut epithelium, and (4) streams of nuclei from the nidi—a process probably never described before. All these processes have been described for the first time in the same insect. It has also been possible to establish all these processes which have been described as separate phenomena in different insects are actually the different phases of the same process.

The working of the oesophageal and the pyloric valves has also been discussed and it has been contended that the terms 'oesophageal valve' and 'pyloric valve' are misnomers

39. A study of the genitalia in some of the Indian Coccinellids (Coleoptera).

S. PRADHAN, Lucknow.

This paper is a continuation of the author's published work on "The Genitalia and their rôle, etc. in *E. indica*" Proc. Acad. Sci. U.P (India), Vol. 5, 1935.

The paper includes a comparative account of the genitalia in some of the other Indian species and it is expected that a closer study will reveal the various lines of evolution within the family Coccinellidæ.

40. On the Scorpions of Hyderabad.

M. RAHIMULLA, Hyderabad (Deccan).

The author has made a preliminary study of five species of scorpions (belonging to two genera) found in Hyderabad. Their salient characters are summarized as follows:—

A. Genus *Palamanœus*—

(1) *P. swammerdami*—Blackish or blackish-purple in colour. Inner edge of hand compressed. 5th caudal segment longer than carapace. Tarsi with 6 posterior and 4 anterior spines. Pectinal teeth—19-20 in ♂ and 16–18 in ♀. It is the largest type of scorpion found here and usually met with under rocky places.

(2) *P. xanthopus*—Yellowish-brown in colour; legs reddish-yellow. Carapace much longer than 4th and 5th caudal segments. Outer portion of the dorsal side of the hand not defined above by a longtitudinal ridge. Tarsi with 4-5 spines. Pectinal teeth—13–15 (♂ and ♀). Not very common.

(3) *P. fulvipes*—Colour as in (2) above. Carapace much longer than any of the caudal segments. Tarsi with 4 anterior and 6 posterior spines. Outer portion of the dorsal side of the hand defined above by a distinct irregular longitudinal ridge. Pectinal teeth—14–16 in ♂ and 13 in ♀. Common and usually found in damp localities, and sometimes in houses.

B. Genus *Buthus*—

(1) *B. pachyurus*—Uniformly black on all sides. Dorsal surface of 5th caudal segment with rounded granular lateral edges: the area between the edges flat, with a median longitudinal depression. Pectinal teeth—22 in ♂ and 18–21 in ♀.

(2) *B. tamulus*—Yellowish-brown in colour. Dorsal surface of 5th caudal segment with elevated lateral keels; the area between these strongly cancave. 2nd and 3rd segments of tail longer than wide. Keels of the tail-back. Two rows of spinüles below on the legs. Pectinal teeth—30–32 in ♂ and 27–29 in ♀. Commonest species of scorpion of Hyderabad, and usually found in houses.

41. Experiments on the sterility of *Ephestia kuehniella* Z. in relation to high temperature (30°C.).

D. P. Raichoudhury *and* S. E. Jacobs, Calcutta.

Cultures of *Ephestia kuehniella* were reared at 30°C. and 23°C. The time of emergence of adults from the two types of culture overlapped sufficiently to enable the high temperature moths to be paired with those reared at the lower temperature. The effect of temperature on the longevity and the number of eggs laid was determined by placing the alternate females (from both types of cultures) at 23°C. and 30°C. immediately after pairing. The percentage of eggs hatching was also determined. Males reared at 30°C. were impotent when young, i.e. aged two days or less, but a small percentage of them (14%) attained potency as they aged. Females reared at 30°C. and aged two days or less gave as high a percentage of successful pairing with males reared at 23°C. as did females reared at 23°C. irrespective of the temperature at which the eggs were laid. Older females reared at 30°C. when the eggs were laid at 30°C. but gave a moderate percentage (60%) of successful pairing when the eggs were laid at 23°C. The conclusion drawn was that a temperature of 30°C. had not only a marked sterilizing effect on the males but also a gradual sterilizing effect on the females.

42. The freshwater fishes of Dharwar.

P. W. Gideon, Dharwar.

This is one of the series of papers dealing with the freshwater fishes of the Karnatak. Although in recent years the bionomics of freshwater

fishes have drawn the attention of several workers throughout India, the light which the study of freshwater fishes throws on problems connected with the control of malaria and other allied diseases has opened such a wide field for research that it may be said that comparatively little is known of the freshwater fishes of India.

The present investigation aims at finding those species of freshwater fishes which act as larvicides in mosquito control. Apart from the identification and ecological aspects of the fishes of Dharwar, with which this paper is mainly concerned, the immediate problem of investigation is the extent to which the larvivorous habit of fishes is specific or environmental.

From a few laboratory experiments carried out at Dharwar there is reason to believe that in some cases this character is purely environmental. A few instances of such a nature are described, but a fuller elucidation of this character is being investigated by experimenting on a larger variety of fishes taken from different environmental conditions.

43. On the structure of the pyloric cæca in a marine genus, *Platycephalus.*

M. Rahimullah, Hyderabad (Deccan).

The structure of the pyrolic cæca has been investigated by the author in two species of the marine fishes belonging to the genus *Platycephalus,* viz., *P. scaber* (Linn.) and *P. insidiator* (Forsk.) found round about Madras coast.

There are 6-7 cæca in *P. scaber*, arranged in two bunches, right and left, and usually consisting of three or four in each bunch, lying on the ventral side of the stomach. The cæca are hidden from view by an envelope of fatty tissue on their ventral surface, and when the latter is removed those of the left side are clearly visible, whilst only two of the right side are exposed, the others of this side lying concealed due to encroachment of the intestinal loops. In *P. insidiator* there are nine cæca which are arranged in two groups of 5 and 4, and are disposed practically in the same manner as in *P. scaber.*

In *P. scaber* the average lengths of the smallest and the largest cæca are 9 mm. and 18 mm. respectively (the average length of the fish being 17·1 c.ms.). In *P. insidiator* the cæca are relatively large, and the average measurements are 20 mm. and 28 mm. respectively (the average length of the fish 28·8 c.ms. in length).

As regards the blood-supply the cæcal veins and arteries have been described. Regarding the nerve-supply the peculiar mode of distribution of the vagus has been discussed.

The histological details have been thoroughly dealt with.

44. Some further observations on the structure and physiology of an air-breathing loach, *Lepidocephalus* (=Syn. *Lepidocephalichthys*) *guntea* (Ham. Buch.) found in Hyderabad.

B. K. Das, Hyderabad (Deccan).

In previous communications on this subject before the Congress the author dealt with certain aspects of the life history, structure, etc., of this fish. He now proposes to describe the following :—

(A) The structure of the gills and other anatomical parts.

(B) The results of the following physiological experiments :—

- (i) Asphyxiation and recovery of the fish from its effects.
- (ii) Effects of injury to the air-breathing organ.
- (iii) Survival of the fish out of water.

45. Further observations on the respiratory mechanism of the frog.

C. P. GNANAMUTHU, Madura.

The frog ventilates its lungs by regular repeated uninterrupted oscillations of the buccal floor. The air rushes into the lung and out of it as frequently as the buccal floor rises and falls. But the forcing out of air from the lungs is not merely by the sucking action of the enlarging buccal cavity and of the elastic recoil of the wall of the inflated lung but also because of the compression of the lung by the flank muscles *m.m. Obliquus externus and interus*. If the buccal floor is thrown out of action the frog breathes with the aid of these flank muscles alone. This fact suggests how the reptilian type of mechanism could have been evolved from the amphibian.

46. Evolution of the vertebral column in Anura.

H. K. MOOKERJEE, S. K. DAS, *and* N. RAY, Calcutta.

In one of his paper (*Phil. Trans. Roy. Soc.*, London, Sr. B, CCXIX, pp. 165–196, 1931) the senior author dealt with the development of the vertebral column in the following examples of Anura, *Rana temporaria, Bufo melanostictus, Bombinator igeneus* and *Xenopus lævis* and showed that the previous interpretation as to the formation of the vertebral centrum was absolutely erroneous. Previously the prevalent idea was that the centrum was formed by the base of the arch, but the senior author showed that it was really formed by the perichordal tube outside the sheath of the notochord. On the dorsolateral side of this perichordal tube, the arch sits on it like a rider on the saddle. The degree of chondrification and ossification of this perichordal tube varies and leads to the formation of an arc-like or a ring-like centrum. In the present paper the authors have been able to show the gradual transition from arc to ring-like centrum in different species, *Rana afghana, Rhacophorus maximus Microhyla rubra* which fill up the gap between the types previously investigated by the senior author. Another interesting feature is that a number of degenerations of the elements which develop in connection with the centrum take place and these do not retain their identity in the adult skeleton.

47. The anatomy of the oral apparatus of the tadpoles of *Megophrys parva* with special reference to adaptive modification.

J. L. BHADURI, Calcutta.

The author describes in this paper the muscular anatomy and histology of the upper and lower lips which form the oral apparatus of the tadpoles *of Megophrys parva*. There is no muscle in the upper lip. The lower lip is, however, provided with a number of longitudinal bundles of muscle fibres appearing in a semicircle below the mouth. The homologies of the muscles that are found associated and modified with oral apparatus are discussed. Further, a correlation between structure and function is also attempted in the light of anatomical findings.

48 The mechanism of bile secretion.

M. K. SUBRAMANIAM, Madras.

Bowen from his researches on sperm and gland cells came to the conclusion that the formation of secretory granules in relation with the

Golgi network in vertebrate gland cells is comparable to the secretion of acrosome by the discrete Golgi bodies of invertebrates. In germ cells the Golgi bodies have a duplex structure whereas in vertebrate gland cells the Golgi apparatus is in the form of a network associated with which no idiosome has been demonstrated. As the arcosome arises in intimate relation with the idiosomic portion of the Golgi complex any comparison of the phenomena of secretion by the Golgi apparatus in gland cells with the production of an acrosome should be followed by a demonstration of the duplex structure of the Golgi network at least in some cases. No definite attempt has been made in this line previously and in the liver cells of *Rhacophorus* it has been noticed that active formation of bile components is followed by differentiation of an idiosome as a core to the Golgi apparatus. The results are discussed in relation with the unexplained observations of Nassonov and Bowen and the conclusion is reached that the chromophobic or idiosomic region which forms a core to the strands or plates composing the Golgi apparatus the masked in the very early stages may become visible during active synthesis of glandular products.

49. Soil moisture and incubation period in *Schistocerca gregaria* Forsk. eggs.

M. AFZAL HUSAIN *and* TASKHIR AHMAD, Lyallpur.

It has been ascertained that the incubation period of the eggs of *Schistocerca gregaria* can be prolonged considerably by controlling soil moisture. It has been possible to keep the eggs alive for 71 days. These eggs hatched 10 days after moistening. The normal incubation period was 13 days. Sand, sandy-loam and loamy soils behave differently under similar moisture conditions. The results obtained are very interesting.

50. Pelagic larva of *Squilla interrupta*.

S. H. LELE, Bombay.

Although a large number of species of *Squilla* and other allied genera have been known from the Indian coastal waters the larval form of none of these has been described. As a matter of fact complete life-histories of only two or three stomatopods from other seas have been worked out so far. Further, those who have examined stomatopod larvae have come to the conclusion that there are many more kinds of such larvae than the number of stomatopod species so far described.

As a result of the examination of local marine plankton carried over for some years, the writer with the assistance of Miss Gae has been able to note the successive changes in the external characters of a pelagic *Alima* larva and trace the latter to the adult form of *Squilla interrupta*. The results of this investigation are described in this paper.

51. A Survey of the fauna of the Dal lake in Kashmir.

G. MATTHAI, Lahore.

The paper contains the results of a preliminary survey of the fauna of the Dal lake in Srinagar made by a party of five research workers from the Zoology Department of Panjab University under the direction of the University Professor from 1st to 15th September, 1936. Animals collected were observed in the living condition and brought to Lahore for further detailed study. Several species are recorded from the Dal lake for the first time. Over 60 species are represented in the collections belonging to the following groups :—freshwater sponges (5), Oligochætes (1), leeches (3), Gastropods (4), Lamellibranchs (1), Entomostraca (11), Amphipods (1), aquatic insects (4), aquatic spiders (3), aquatic ticks (2), fishes (9), frogs (4), aquatic birds (19).

52. The Golgi Apparatus in Protozoa.

C. L. BHATIA, Lahore.

Whereas the homologies of the Golgi apparatus in the Sporozoa seem to have been finally established, considerable diversity of opinion exists with regard to Mastigophora, Ciliophora and Sarcodina.

The author has studied four types, viz. :—

(*a*) *Herpetomonas muscarum,*
(*b*) *Nyctotherus cordiformis,*
(*c*) *Opalina ranarum,* and
(*d*) *Amœba proteus,*

of which the first belongs to the Mastigophora, the last to the Sarcodina, and the remaining two to the Ciliophora.

In all these forms it has been found that the Golgi apparatus presents general similarity of form and structure, resembling the Sporozoan type as described by Hirschler (1914) in *Monocystis* and hence also the metazoan apparatus.

53. The quantitative analysis of the Protozoa of Lahore soil.

AHMAD HUSAIN, Lahore.

To estimate the number of trophic and cysted protozoa of the soils, Cutler's dilution method was employed. Samples of barren, sandy and garden soils were taken from the depth of 9″ and examined weekly.

In the barren soil *Bodo ovatum* and *Amœba limax* were present in the largest number while *Colpoda manpassii* was found to be the least.

In garden soil *Balantiophorus elongatus* and *Bodo caudatum*-were found to be most abundant while *Amœba limax* was observed to be rare.

Sandy soil from the bank of the river contained the largest number of *Colpoda maupassi* and *Colpoda steneii.*

54. Cestode parasites of sheep and goats in the Punjab.

MOHAMMED AMIN, Lahore.

About eleven species of Cestodes belonging to four different genera have been found so far.

Considering the wide range of variation in the genus *Moniezia,* the author has recognized two species only, *Moniezia expansa,* and *Moniezia benedeni.*

Six species of *Avitellina* have been found, of which two are considered to be new. They have been identified according to the general form of paruterine organs and the arrangement of testes.

Stilesia is represented by two species only, *S. globipunctata,* and *S. vittata.* The latter species was formerly known to occur exclusively in camel.

Helictometra is recorded from India for the first time. It is represented by one species, which seems to be new.

The follicular arrangement of the testes, so far described only in some species of *Tetraphyllidea* and *Trypanorhyncha,* has also been studied in certain species of *Avitellina* and *Helictometra.*

55. The Musculature of the Genitalia and the processes of Oviposition in the Ak-grasshopper, *Poecilocerus pictus.*

S. S. KAPUR, Lahore.

In this paper the author deals with the muscles of the genitalia of both male and female Ak-grasshoppers. Several groups of muscles of the pre-genital segments conform with the classification of the abdominal muscles, e.g., *dorsal muscles, ventral muscles, lateral muscles, transverse*

muscles, and the *spiracular muscles*. The musculature of the various parts comprising the genital and postgenital segments (e.g., of Aedagus, Valvulæ, Intervalvulæ, Spermathecal ducts, and Ejaculatory sac and its ducts, etc.) is separately treated.

The muscles of the *tympanum*, *cerci*, *spiracles*, and hinder region of the alimentary canal are also dealt with in this paper.

Oviposition.

The ovipositor digs holes in the ground in the vicinity of the Calatropis plants on which these grasshoppers feed. The eggs are laid within these holes. The eggs as they come out of the oviducal opening are accompanied by a large amount of viscous frothy material which soon hardens and forms a vaculated mass surrounding the eggs and forming the *Egg-pods*.

Enumerating different digging movements of the ovipositors, the author describes the opening of the valvulæ to be effected by their powerful *levators* and *depressors*, their closure by the muscles of the anterior intervalvulæ, the downward thrust being produced by the *protractors* of the lateral apodemes, and the twisting movements being brought about by the *transverse muscles* of the successive dorsal terga.

56. Some Coccinellids of the Punjab.

A. P. Kapur, Lahore.

The characteristics and the position of the family have been discussed.

Fifteen species belonging to ten genera were gathered during the year 1935-36. Their important morphological characters, food, distribution and life-history (as observed under natural surroundings) of some forms are also given.

In the Punjab the principal hosts of *Epilachna 28-punctata*, Fabr. and *E. 12-stigma* Muls are different from those found in Mysore, Bihar, Bengal and Cuttack. Here *E. 28-punctata* chiefly feeds on egg-plant while *E. 12-stigma* is commonly found on Cucurbitacæ. In Mysore the former attacks potato while in Bihar it damages Cucurbits. In Bengal and Cuttack on the other hand *E. 12-stigma* feeds chiefly on egg-plant. A few species of *Scymnus* (Kugel) have been observed to feed on mealy-bugs and mites found on Castor plant. *Thea bistonotata* Muls and *Halyzia Sanscrita* Muls, besides feeding on aphids also take fruiting bodies of certain fungi. *Adonia variegata* Goeze, attacks the eggs of *E. 28-punctata*.

The developmental period is greatly effected by temperature but under natural conditions it takes less time than what has been recorded in the laboratories.

57. Variation of Spots in Coccinellidæ.

A. P. Kapur, Lahore.

Variation of spots in *Epilachna 28-punctata* Fabr. and *E. 12-stigma* Muls, has been given. The markings on the head, prothorax and elytra in *Adonia variegata* Goeze also present a great range of variation. In the majority the black area predominates in the region of the head and prothorax. The black spots on the elytra present about 16 different patterns. In some of these the spots are absent while in others there is a great increase in the black area resulting from the confluence of many spots at a time. Some of the patterns resemble the elytral markings of several other genera belonging to the tribe *Hippodomiini*.

Increase in size of the black area resulting in the blackening of the elytra has been observed in *Cheilomenes sexmaculata* Fabr. and *Coccinella septempunctata* Fabr.

SECTION OF ANTHROPOLOGY

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Presidential Address

AN ETHNOGRAPHICAL STUDY OF THE COORGS

INTRODUCTION.

In opening the proceedings of this section, I have great pleasure in welcoming you. All of you have come as delegates from different parts of India and I look forward to your contributions to the deliberations of this section, and endeavour to find solutions for the many difficult and interesting problems on the study of Man. It is now twenty-four years since the Indian Science Congress was inaugurated by the joint efforts of the leading scientists in India. The first meeting was held in the Royal Asiatic Society of Bengal, Calcutta, at which I had the privilege to serve as one of the Presidents. Since then the annual meetings were held in some of the University centres in rotation. This Congress, recently named the Indian Science Congress Association, has given rise to increased scientific activities by encouraging directly or indirectly teaching and research. I have attended many of the meetings and I now look back with pleasure on the many-sided achievements in science through the help of this Association.

We are now chiefly concerned with the progress of research in the study of Man. Before 1914 there were contributions of individual writers from all parts of India, which were embodied in the Census reports and in the bulky volumes of the Tribes and Castes of the various provinces. These were no doubt the brilliant achievements of the Ethnographic Survey inaugurated by the late Sir Herbert Risley in 1901. Thus abundance of materials both in Physical and Social Anthropology were collected and published at various intervals. A fresh start for the advancement of this Science was given by the Indian Science Congress Association, and by the late Sir Asutosh Mukerji, in the Calcutta University, where arrangements were made for advanced teaching and research.

Presidential addresses and papers read by the delegates year after year bear testimony to the growing popularity of the study of Man. At the outset the papers were mostly cultural. Subsequently there have been contributions in Physical

Anthropology as well. There has thus been considerable advance in research.

The scope of Anthropology is now very much broader. It has now two main departments which differ widely in their functions. On the physical side Zoology looks backwards on Palæontology, while 'Physiology beckons to Psychology across the no-man's land represented by psycho-physics'. There is again Human Biology with heredity, environment and genetics. On the Cultural side which covers Archæology, History and Economics, attention must be paid in turn to industries, arts, institutions, beliefs, and not the least of all to language as the key which unlocks the inmost sanctuary of the mind. The problems connected with them form a fascinating branch of what is known as Ethnology. It is only by students engaged in study and research that the cultural history of man can be elucidated. Various kinds of the dissemination of culture must also be determined. For the sake of greater precision, it must be said that Anthropology should not be given a narrow sense of Somatology. The physical and the cultural sides of the study of Man must also be dealt with in strict conjunction, however different may be the special methods required in each case. Surely the interaction of body and mind is too subtle and all pervading to permit of any divorce between the material and the spiritual aspects of human nature. Thus far I have made a few observations on this fascinating subject. It may be said that in India much has been done and more remains to be done to build up a school of Indian Anthropology and Indian Ethnology on organised lines for which trained young men are necessary. This is the work of the Universities.

As you are aware, the ethnographic configuration of India has been mapped out. I have myself had the opportunity to fill the gaps in the west coast of South India. The ethnographic survey of Mysore was recently completed. The only remaining gap to be filled up is Coorg. During the last two years, I was engaged in the study of the Coorgs. I felt that the materials collected will be of interest to my fellow workers in Anthropology and have, therefore, devoted the rest of my address to the subject of Coorgs :—An ethnographical study.

The province of Coorg is situated in a semi-isolated portion of the Western Ghats. This mountainous and jungle-covered country was inhabited by two distinct communities, namely, the Yeravas and the Coorgs. The former had to retire to the hills before the southward march of the Aryans and others, and found an asylum from the aggressive invaders. Probably at a somewhat later period, the splendid race of Coorgs or Kodagas found in the jungles of Coorg the means of satisfying their hunting propensities; while the narrow passes afforded an opportunity for their highly developed instincts to carry on their predatory excursions into the country of the wealthier and less

warlike neighbours. Even now their sporting and fighting proclivities reveal themselves in their socio-religious ceremonies. During the past three centuries they were known to be a compact body of mountaineers who resembled very much the Scotch clan, and differed greatly from the people of the plains in their manners and customs. Their special characteristics are the outcome of their habitat which helped to develop a special type of culture. The mountains of the province with their immense virgin forests have protected them from aggression and conquest.[1]

Composition of the Coorgs.—Writers who have made an intensive study of the Coorgs differ in their conclusions. They have also ignored the difference between race and culture as also between nature and nurture. Linguistic terms such as Aryans, Dravidians and Pre-Dravidians have caused a good deal of confusion in Anthropology. A racial history of the Coorgs is under preparation, and till then it is sub-judice. Coorg inscriptions throw very little light on the early history of the Coorgs themselves. They merely show that the province was successively connected with the Ganga dynasty, Hoysala kings, the Nayaks of Belur under Vijayanagar Empire, and the Lingayat Rajas of Coorg, as also with those of the Bednur family. It is said that under these various governments new settlers must have been introduced into the province, and that the troops themselves were supposed to be the descendants of the conquering army of the Kadamba kings whose capital was at Banavasi in the Sode District of North Canara. This conjecture is supported by the Cauvery Purana in its account of Matsyadesa, the Puranic name of Coorg. After the decline of Vijayanagar, the province of Coorg fell into the hands of the insurgent chiefs of the old Government who were so well known as Poligars. Till then the province seems to have had no political importance. The chiefs were called the Nayaks who governed the small territory. Their power was overthrown by the influence of the Ikkeri prince who came to Coorg and settled in Haterinad. Finally the whole province passed on to Haleri Government. The Coorgs escaped the ravages of Malik Kafur. The expatriation and captivity by Tippu Sultan of a large body of Coorgs and their families in Seringapatam from 1785 to 1792, and their forcible conversion to Islam, as also their return home after Tippu's death emboldened the Coorgs who allowed their countrymen to return to their former faith.[2]

The Coorg Rajas themselves were aliens to the country and were Lingayats, while the Coorgs were the followers of Ancestor Worship. They were the most numerous in the north-west of

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[1] Richter, *Manual of Coorg*, p. 4; L. Rice, *Mysore and Coorg*, Vol. III, p. 216.

[2] Richter, *Manual of Coorg*, p. 231.

the province where they were closely allied with the Mysoreans. In Padinalkanad the Malayalam element was predominant. In Tawnaddenganad and Surabi Muttanad, the Tulu Gaudas and Bunts had their influence felt. Wynad which once formed part of Coorg must have afforded a passage to the immigrants from Malabar. Wynad Chetties had their settlements in Coorg as their house-names testify. From all these historical facts it may be conjectured that the Coorgs are not an unmixed race. Besides their physical characteristics, the Caucasian and Mongolian physiognomy, a fair and dark skin, the house-names of some of the Coorg families clearly point out to Mysore, Tamil and Tulu origins. Even at present strangers are received and incorporated with them. Further their language and demon and ancestor worship tend to show that they belong to the Dravidian stock. These physical traits or varieties are biologically useful and related to mental capacity and intellectual endowment. Applying this maxim to Coorgs, their mountain habitat, climate, food and occupation are responsible for what they are at present. It is interesting to note that these factors have differentiated them from the people of the plains.[1]

Endogamous groups.—The Coorgs come under four separate groups, namely, Amma, Sanna, Malla and Boddu Coorgs. Amongst these groups Amma and Sanna Coorgs are found in all parts of the province. The Boddu Coorgs are found to the north of Mercara. The Malla and Sanna Coorgs are united and are no longer distinguishable. Endogamy has become customary and is well on the way to becoming law. The Coorgs are the major and dominant community in the province. A few minor and alien tribes adopting their manners and customs as also their dress are trying to assimilate themselves with the Coorgs.

Exogamous clans.—It has been already said that the clans of the Coorgs resemble those of the Scotch Highlanders. Even in point of their habitat there is a kind of similarity. As many as more than 100 names of the Coorg clans have been collected by me. Most of them are their local house-names. Some are alien. Between the members of the same family name, there is no intermarriage.

Economic life of the Coorgs.—The economic life of any community includes the material culture of Man which may broadly be divided into five stages, namely, (1) the collective life, (2) pastoral stage, (3) the horticultural stage, (4) the stage of settled agriculture or village, urban economy, and (5) the stage of commerce and industry.[2] The prime necessity of primitive man is food-quest. He was first the collector of what the virgin forests provided for him, and his time was mostly occupied with the quest for food. He had no tools at the outset, and his hand

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[1] G. A. Dorsey, *Why We Behave Like Human Beings*, p. 47.

[2] L. K. A. Iyer, *The Mysore Tribes and Castes*, Vol. I, p. 380.

was the first tool. Gradually he learned to make a number of them to increase his food supply. The question arises whether the initial stage of acquisition was accompanied by a group co-operation and solidarity. The earliest group must have been very small. Since most of the food secured was eaten on the spot, it might be supposed that food-gathering was an individual enterprise. This was the first stage in human economy, the individual search for food. Such instances are not unknown in South India, where the jungle tribes have passed the first three stages which have become subsidiary. The Coorgs have now reached the last three stages.[1]

Coorgs as hunters and fishers.—The Coorgs have been skilful hunters and are even now keeping up their hunting habits. Bows, arrows and slings once used by them have become extinct. They have their bill-hooks, spears, swords and matchlock guns. The bulk of them hunt partly for sport, and partly for supplementing their vegetable diet. Pigs are coursed with dogs, brought to bay, and killed with spears which are shorter, heavier, and broader in the blade or with ordinary fighting spears. Old boars fight fiercely, and hunters are sometimes wounded or killed. Most animals are trapped. When they go in party for hunting they have dogs which are set on tracking. When they bark and the hunters approach, the animal is disturbed. It either tries to run away or charges them. In the latter case they aim at the animal with guns and kill it.

In their leisure hours the Coorgs engage themselves in fishing in streams, rivers and tanks. They use nets. The ordinary one is the *thaduvala* which is spread across the stream to prevent fish from escaping. At a distance of almost about a furlong they spread another net, so as to drive the fish within the net. When the nets are brought closer many of them are caught by hands. They use also another net known as *beesuvala* by which they catch other varieties. Sometimes they catch fish by shooting and throwing baits.

Agriculture.—Agriculture of Coorg which is of the rudest kind is similar to that which prevails in other parts of India. It is a system of rural economy formed at a remote period and transmitted for ages unchanged. Attached to the ancient practices the cultivator views with dislike any attempts at innovation. Industry of the people of the highlands is confined exclusively to the cultivation of rice. The narrow valleys between two high grounds is very productive. The agricultural implements are few and of the rudest kind. And yet the yield has furnished an unfailing supply from ancient times both for consumption and export to Malabar. Wherever practicable the valleys have been formed into flat terraces for cultivation.

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[1] L. K. A. Iyer, *The Mysore Tribes and Castes*, Vol. I, pp. 383–385.

The agricultural year, as in other parts of South India, begins about the middle of April. With the first showers in April or May the ploughing commences. On an auspicious day before sunrise the house lamp *Talli-alki-balake* (dish-rice-lamp) which plays a conspicuous role on all festive occasions, is lighted in the inner verandah, the members of the family assemble and invoke the blessings of their ancestors and Cauvery Ammen (Deity of River Cauvery). The young men make obeisance to their parents and elders, and drive a pair of bullocks to the paddy fields, where they turn the heads to the east. The landlord now offers cocoanuts and plantains, rice and milk to the presiding deity of the *nad* (division of a District) ; and lifting up his hands to the rising Sun he invokes his blessing. The oxen are yoked and three furrows are ploughed when the work is finished for that morning. Of the upturned earth he takes a clod to the store-house or granary, offers his prayers to Siva to grant him an increase of one hundred times. The recognition of the source of material wellbeing is due to their industry to command success. From 6 to 10 A.M. the ploughing is continued till the fields are turned two or three times. Then the borders are trimmed, the channels cleaned, and the little banks repaired to regulate water.[1]

Regulated by the monsoon rain, rice-transplanting takes place during July and August. The women covered with umbrellas called *goragas,* that rest on the head and protect the whole body, pull out the plants from the nursery and tie them in small bundles which are collected in one spot. Meanwhile the submerged fields are repeatedly ploughed and levelled, till the soil becomes as soft as treacle.

All the members of the family, standing in a line knee deep in the muddy fields, begin the transplanting, in which women are not expected to join. The bundles are conveniently deposited on the field, and each man takes a handful of plants at a time into his left hand, and presses into the mud with great rapidity seven or eight seedlings together keeping a regular interval of six inches. Before the completion of the largest field an open space of 10 feet wide is left throughout the whole length. This is the Coorg race ground offering a jolly good sport which greatly exhilarates their monotonous work. From the men engaged in the work, fifteen are selected for the race on 100 *butties* of land. Wearing merely a pair of short drawers they are eager for the run for which their strong legs qualify them. The sign is given and away they scramble, plunge and stagger in the deep mud amidst roars of laughter, which greet the unfortunate man struggling in the mud. Having reached the opposite bank, they return in the same way struggling close to the winning post. Only four or five win the race. The first comer is rewarded with a piece

[1] L. Rice, *Mysore and Coorg.* Part III, pp. 29–32.

of cloth, the second with a bunch of plantains, the third with a jack fruit and the fourth with a bunch of oranges, and the fifth with parched rice.[1]

When all the fields are planted, a feast is given by the landlord. As a protection against evil eye, some half burnt bamboos about six feet are erected in a line throughout the middle of the fields. It is now the farmer's business to regulate the water supply of each field, and to fill up the holes made by crabs in the embankments. The weeding is then attended to and the failures replanted. At the end of October when the ears of corn are fully out, small huts on high posts are erected, one for every 100 *butties*, for the watch men who guard the crop against wild beasts and at times fire a gun to scare them away. In November or December the paddy gets ripe, and the feast of the first fruit or *Huttari* is celebrated after which the paddy may be reaped. The water is drained off the fields. The paddy is then cut down with a sickle close to the ground and spread out to dry. After six or eight days it is bound into sheaves and carried home and stacked in a heap with the ears inside. In January or February, chiefly in moonlit nights, the sheaves are taken down to the threshing floor, spread round a stone pillar in the middle and trodden out by bullocks and buffaloes, when the paddy is winnowed. The best quality is reserved for seed and the rest stored up for consumption or sale.

The cultivation of coffee is another important industry in Coorg, and the favourable condition for this industry has long been known to the natives. Its introduction was due to the Moplas, and the Coorgs borrowed it from them. It became a popular industry which effected great changes in their economic life. But the depression which had occurred in the past several decades led to the abandonment of many estates and the renewed interest in the revival of their rice cultivation. Tea and cinchona which were tried by the European planters, met with no decided success.

To a large number of Coorgs the cultivation of cardamoms was at one time second in importance to that of rice, and the possession of a fine cardamom jungle was regarded as a mine of wealth. In the time of the Coorg Rajas, cardamoms were a state monopoly and were purchased at a fixed rate from the Government.

Of the fruit trees, the orange plantations are common all over Coorg. The Coorg oranges are famous, and as common as plantains. The best variety is sweet and luscious loose jacket, so called because of the rind of the fruit being almost detached from the pulp. Pine apples, pomegranates and jack fruits are abundant and of luxurious growth. The areca nut production is

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[1] L. Rice, *Mysore and Coorg.* Part III, pp. 29–32.

another big industry in some parts of Coorg. Honey and beeswax are of great importance to the Coorgs. The latter is one of their articles for sale and export. The native bees are rather small, dark brown or black. Most swarms live in hollow trees or among the rocks. But the Coorgs make hives, put them near the old swarms, and wash them inside with honey in the hope that new swarms will settle in them. Such swarms belong to the maker of the hives while the swarms, belong to the finder. The hives are made in hollowed out logs loosely fitting inset ends. The hives are usually three to five feet long and about one foot in diameter. They are laid horizontally in the forks of trees, often as much as twenty feet from the ground. This is to protect the swarm from animals. To obtain the honey and wax, the swarm is first stupefied with smoke from torches. The end of the hive is then fried out and all the comb is removed at once destroying the colony. A large wooden bowl of special type is used for collecting the honey. Another method of gathering honey is to take a number of pots, with small holes bored on the side, the inside of which are either washed with honey or rubbed with beeswax. These pots are placed in the forest at a distance from their homes. Bees gather and form a colony in each pot. The inmates of the house go there during night, cover them with a kerchief, bring them home, and place them conveniently on a plank five feet from the floor, and allow them to remain until the comb is developed. When honey is finally gathered by pressing, it is strained through cloth and preserved in vessels with their mouths closed. This honey is considered best, and after it has become thickened, it is usually kept in vessels before being used. After the honey is pressed out, the residue is boiled and strained to collect wax which is poured in shallow vessels where it becomes solidified. It is then sent to the market for sale.[1]

Routine dietary of the Coorgs.—The Coorgs have an abundant supply of food materials. They rear pigs and goats. Their chief article of diet is rice and on festive occasions cakes and sweetmeats are prepared. Earthen vessels are used for cooking and for cakes and puddings steam ovens are used. Their kitchens are remarkable for the cleanliness of the cooking vessels in use which are in charge of the cooker *manepane karti.* Like their Hindu sisters the Coorg women attend on the elderly members before they take their meals. Before taking meals a little of the cooked food is offered separately to the family deity (*mane devata*) at the *Kanne-Kombane.* They take an early breakfast of rice seasoned with pickles and curds ; a substantial meal is taken at noon time with rice and curry. At 3 P.M. Kanji is again taken as in the morning and in the evening a hearty meal of boiled rice with vegetable or meat curry and

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[1] Richter, *Manual of Coorg*, pp. 107–109.

other condiments. Toddy of the *bainy* palm (*Caryeta urens*), also a kind of beer made of fermented rice-brandy and *arrack* are their usual beverages. Of late it is said that European liquors are their favourite beverage at festivities when all join with equal ardour and devotion.[1]

'The industry of the Coorg women deserves much praise. They rise early, clean the kitchen, cook and do all kinds of domestic work. They also bear a large share in the labours of the farm. The men plough the fields, transplant and reap the rice. The women carry manure, pluck weeds, fetch home and clean the paddy. The men do no menial work. They leave that to women and servants, and enjoy a dignified repose chewing betel and gossiping. Some are expert tailors. Others with their gun on shoulder wander through the jungles in search of game. The Coorg hospitality is proverbial, and the Coorgs enjoy visits from relatives and friends.'[1]

The Coorg house.—The Coorg houses, like those of the Nayars of Malabar are generally situated close to their paddy fields on a sheltering slope of '*Bane*' land surrounded by clumps of plantain trees, sago palms, betelnut palms, orange, jack and guava trees. A coffee garden and a small plot for kitchen garden is seldom absent on the Hittalmanedala land. In the compounds of some houses there is also a small pond well stocked with fish. The position and the type of building very much resemble those of the Nayars of Malabar and Cochin. The approaches of the old Coorg house strongly mark the design of fortification and tradition points back to a time of general feuds, when chief fought with chief, and clan with clan. Deep *Kadangas* or trenches with high embankments still testify to the memorials of the warlike state of affairs in former times. These war ditches intersect the mountainous district in every direction. They have resisted both the furious attacks of the contending armies, and the force of the annual monsoon. A deeply cut passage (*woni*) paved with rough stones and overgrown with shady trees, its sloping side walls decked with a variety of ferns, leads one in angular lines to door-way passing under an outhouse. Houses are situated in the middle of their plantations far remote from the public road. A paved courtyard is surrounded on all sides by stables, store-rooms and servant's quarters, in front of which is the main quadrangular building which is provided with one story, and is raised about three feet from the ground. All the buildings are roofed with bamboos and thatched with rice straw which is annually repaired and renewed. Many of the houses seen by me conform themselves to the original plan and design and are tiled. There is generally an open square hall in the centre known as *nudumane* or *butte*, the four sides of which are provided with rooms for the inmates to occupy. On

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[1] Richter, *Manual of Coorg*, pp. 107–109.

the front side of the building there is an open verandah which is the reception hall. It is raised and covered with a wooden plank *aimara* two or three feet broad, so as to form convenient seats for the male members and visitors. From it rise three or four wooden pillars, square, round and tapering and sometimes carved. The floor is well beaten with mud and cleaned with cowdung. The ceiling is of wood, arranged in small compartments. In some, the verandah is separated from the inner hall by a wall with a sort of window or lattice made of wood. This aperture like the principal door-posts is elaborately and handsomely carved in flowers and figures, leaving open space between, just large enough to peep through without being seen. It is a contrivance designed chiefly for the benefit of the Coorg women who are curious to see visitors as their Musalman sisters behind the purda or screen. On the right side of the veranda there is the main door leading to the inner hall which is lit by the sky-light formed by the junction of the four slopes of the inner roof into an open space (*mittam*) which is a masonry reservoir in which rain water is collected and drained off by an underground passage. The inner roof is supported on four pillars, resting on thick broad slabs of jack wood upon the walls of the reservoir, and forming convenient seats for the inmates of the house, the inner rooms of which are without windows and open by small doors into the central hall only. On the side diagonally opposite to the door of the veranda and like the inner right corner, there are two doors leading to the exterior of the house. The first room of the inner hall is occupied by the master of the house and his wife. The next room is the kitchen (*adu-mane* or *umbala-mane*) dining room whence the smoke issues and fills the whole house coating and preserving the wood-work. The small room of the remaining two wings are tenanted by the married couple, the widows and unmarried women. One room near the left corner is set apart as sacred to the family deity (*mane-devata*) and also known as *Kanni-Kombare.* From the ceiling are suspended match-locks, the wooden bells for cattle, the trappings for pack bullocks and other domestic utensils. The space under the roof and above the ceiling, the wooden floor covered with a thick layer of earth to keep the rooms below dry and fire-proof, serves for storing bags of rice, baskets, pots and culinary provisions. There is also a deep well built with stone in the compound to supply water for cooking purposes and another hut is built by the side of the paddy fields for a bathing in hot water.[1]

Furniture.—The furniture in a Coorg house bear ample testimony to the simple habits of the inmates. Wooden cots are generally used with straw coir or cotton mattresses and cushions,

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[1] Richter, *Manual of Coorg*, pp. 128–131. *The Cochin Tribes and Castes*, Vol. II, pp. 8–12.

sheets and blankets; and on the floor they have coarse mats for rubbing their feet before going to bed. Occasionally they use wooden stools. On days of religious ceremonies they sit on mats. A wooden shelf is fixed to the wall in each room to keep their brass vessels, plates and lamps. Rattan or wooden boxes contain their clothes and jewels. There is always a spittoon in one of the corners of the room. Where there is a baby, a rattan cradle is suspended from the ceiling within reach of the mother's bed. The air of the room with closed doors and no windows is at night very stifling, and extremely unwholesome in cases of sickness. Young Coorgs of the present generation have better houses and good furniture as also comfortable arrangements in the European style. Some of them were seen by me at Mercara and in the neighbourhood.

Physical and mental characteristics.—Judging from the physical characteristics of the Coorgs, such as stature, span of arms, cephalic and nasal indices, comparative length of the upper limbs, facial angle, colour of skin, etc., they rank very prominently among the people of South India. Their maximum, minimum and average stature, span of arms, cephalic and nasal indices are given below :—

	Stature	Span of Arms	Cephalic index	Nasal index
Maximum	179·0	184·5	89·0	89·4
Minimum	141·4	146·1	73·7	58·3
Average.	160·2	165·3	89·4	73·9

The Coorgs are a hardy race and bear with fortitude much hardship especially during the monsoon months when they are engaged in cultivation. Exposed to all the inclemencies of the weather, they retain their vigour most admirably. In the times of the Rajas and in their marauding expeditions, they have proved themselves to be brave soldiers, and are much dreaded for their fierce intrepidity especially in their encounter with the enemies. Military officers have often remarked on their excellent fitness for the formation of a few regiments. The intellectual and moral qualities of the Coorgs have been for ages dormant for want of opportunities. Consequently they are said to be ignorant and superstitious in common with the people of low culture. During the past fifty years under the vigorous efforts of the English educational system marked signs of improvements have been observed. English schools for boys and girls have been started in the important centres, and they have been taking advantage of them. Coorg students are by no means deficient in intellectual brightness or plodding acquisitiveness. Their standard of morals is, by no means, inferior to that of their brethren in other parts of India.

Dress and ornaments.—The full dress of a Coorg consists of a long coat (*kupasa*) of dark-coloured cloth, open in front and reaching below the knees. The sleeves end below the elbow

and show the arms of a white shirt which is generally of the English pattern. This is folded across and confined at the waist by a red or blue girdle wound several times round, and knotted on the left front. On the right front the Coorg short knife (*pitcha katti*) is stuck into the girdle having an ivory or silver handle or hilt and fastened with silver chains. The large broad-braided waist-knife (*odi-katti*) is very rarely worn. Its place is at the back, where it is carried in a brass clasp with its point directed towards the left shoulder. Like the kukri of the Ghurkas it was a formidable weapon in hand to hand fighting. It is now used only as a test of skill and strength on festive occasions as when a bridegroom is expected to cut through the trunk of a big plantain tree at one stroke. Their head-dress is of a red kerchief or the beautiful fashioned turban rather large and flat at the top and covering a portion of the back of the neck. They are found in all shades of complexion, and when dressed in this costume they look very grand. Now-a-days the officers and even students adopt the European style of dress in preference to their own.[1]

The women are more conservative in their mode of dress. It consists of a white or light blue cotton jacket with long sleeves fitting tight and closed up to the neck. The shirt is white muslin or blue cotton stuff, wrapped several times round and tied at the waist by means of a string. One end is brought over the bosom and knotted on the right shoulder. The other end, gathered into folds is worn contrary to the usual fashion of Hindu women at the back. The head is covered with a white muslin or coloured kerchief, one end of which encircles the forehead, and the two corners are joined together at the back, allowing the ends to fall over the shoulders.[2]

Social Organization of the Coorgs on the West Coast of India.

Marriage regulations.—' The marriage customs of the Coorgs at present ', says Richter, ' is a curious medley of old and new rites, fashions and notions '. In former times their marriage festivities had a communal character. ' On an auspicious day a family would call together the whole village comprising all the families of the rice valleys occupying farm houses to a feast. The youths would have their ears pierced by the village carpenters to wear ear-rings, and the maidens had rice strewn on their heads. This was called the marriage feast. The whole community feasted together, and the young people were at liberty to go in search of husbands and wives.' This communal character of the wedding has changed. Young men eligible for marriage at present express their desire to their parents, grandparents or to the senior members of the family who look out for suitable

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[1] *Imperial Gazetteer of India,* Mysore and Coorg, p. 29.
[2] *Ibid.*

girls not in any way related to them. In other words all consanguinous unions are avoided in matrimonial alliances. Among the prohibited degrees are: (1) the descendants of the father's side of the same family name; (2) the descendants of the mother's sisters and (3) cross cousin marriages. A friend of each of the contracting parties becomes the intermediary or *Aruva* (one who knows) and he is the master of ceremonies. The father of the young man or his elder brother with *Aruva* goes to the house of the young woman where their advent is expected. On the return of a favourable answer, the whole house is well swept and cleaned and a lamp lit, when the *Aruvas* on both sides with the leading elderly members of respective families stand before it, facing each other, and shake hands together in token of the inviolable contract having been concluded in the presence of those assembled there. Such betrothals are rarely broken. In the event of death of the bridegroom before consummation of marriage, the bride becomes a widow. She is then entitled to an inheritance and sustenance in the bridegroom's family and may enter into conjugal relations with his brother or first cousins.[1]

Wedding ceremony.—The wedding in Coorg as elsewhere takes place in spring (April and May), when the rice valleys are dry and there is very little work to be done. The day for the wedding having been fixed in consultation with the local astrologer, invitations are sent round by the *Aruvas* to the relations of the bride and bridegroom, to the married Coorgs of the same village, to the friendly neighbours of other castes and even to Mohammedans. Wealthy families of official aristocracy invite European officers and planters by sending printed wedding cards. The preparations for the wedding are made ready. The larger and fatter the pigs, the more abundant and stronger, and greater will be the glory of the feast. On the morning of the wedding day at about nine o'clock the invited guests assemble in festive array at the houses of the bride and bridegroom; and while the women go inside the house, and give a helping hand to the mistress, the men are accommodated in the spacious veranda or in temporary sheds in the courtyard, and served with *pan supari* to assist 'the flow of village gossip' which is now and then interrupted by the noisy band of musicians. Meanwhile the bride and bridegroom in their respective houses are bathed, neatly dressed and adorned in their best. The young man has been duly shaved and dressed in his new *kuppasa* (coat) with a long red cotton or silk sash round his waist, and fastened into it the new *picha kathi*, a present from his father, together with a watch, jewelled gold rings on his fingers, a chain round his neck and ornaments into his ears, and a carefully tied turban

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1 L. Rice, *Mysore and Coorg*, Part III, 231, 232; Richter, *Ethnographical Compendium*, 29, 30.

in the approved Coorg fashion. A bright coloured handkerchief thrown over his shoulder completes his dress. The bride who is fully decked out is left to the care of her friends. In the house of the bridegroom the wedding party proceed with music to the *Kaymada*, carrying a light which has been kindled at the sacred house lamp and has ignited an earthen lamp there, invoke the blessing of their ancestor in the undertaking. On returning to the house the principal members of the family enter first into the inner hall and the younger men follow and offer their customary salutations. At the auspicious hour (*muhurtham*) the bridegroom asks permission of the master of the house and the elders to seat himself on the low three-legged stool kept in readiness and placed upon a carpet placed between two lighted brass lamps. These lamps trimmed with many wicks stand in metal dishes filled with rice, by the side of which is a spouted brass vessel with milk. On the bridegroom being seated, the master of the house takes a handful of rice and strews it over his head and shoulders uttering the words 'Live well and prosper in God's favour', gives him a sip of milk and drops a piece of money or other present into his lap, and passes on. Four men closely related to him do likewise. Then five of the nearest female relations, and the mistress of the house repeat the same formalities. Then the guests, males and females, assembled there do likewise. Old people touch only the bridegroom's shoulder, those of equal age shake hands, while those below him touch his feet as a mark of respect. As the presents accumulate, they are taken care of by a friend, who sits near him and attentively watches what and by whom they are given. Widows and widowers do not take part in the proceedings because of their being unlucky.

In the house of the bride the same ceremony takes place at about the same time, but women have precedence over men. After this, the bridegroom rises and takes his meal with a group of 12 of the nearest relatives (groomsmen) and the *Aruva*. The guests who are invited are sumptuously entertained in the leafy shed put up for the occasion. Various kinds of liquor are greedily consumed, and the stronger it is the more it is relished. During and after feasting the music makes a discordant deafening noise.

After the feasting the bridegroom's party proceed to the bride's house which is generally some miles distant. On such occasions young Coorgs delight in a 'cavalcade' preceded by a band of musicians, the brass-horn now and then sending forth a jubilant blast of shrillness that penetrates over hill and dale to announce the approach of the bridegroom. On arriving near their goal, where on the open green some plantain stems are fixed on the ground as a barrier, the company stops and, having sent a messenger, awaits his return. Now the bride's party come to meet them, and some of their servants bring chairs and mats along with refreshments. Salutations are exchanged and the plantain stems are cut through with *odi*

kathi. Both parties with the united efforts of the musicians advance to the house. The bridegroom is received by his parents-in-law. After the customary salutations, refreshments of *pan supari* are freely handed round. Then a meal is served and enjoyed with liberal potations. The bride is conducted by her maids over an outspread cloth into the bridal chamber, where she is seated on a low stool. The bridegroom's party approach her and repeat the ceremony of rice-throwing which was performed at noon by the bride's relations. At last the bridegroom who was seated on a low stool all along is conducted to the bridal chamber, and is seated by the right side of the bride who with bent head sits veiled all over. Soon he rises and strews over her and gives her some milk to sip, but speaks nothing. He then presents her with a small bag containing a silver or gold ring, a gold coin for her *pattacku* or necklace and some silver coins. Then both eat together for the first time, being served by some woman of the house. After this wedding meal the young couple have the exchange of looks and words. The bridegroom grasps her hand leads her out of the house, and this act of possession constitutes the essential part of the ceremony. He then returns home with his wife accompanied by his party and the band of musicians. If the home is distant the young wife with the bride's maids are conveyed in a bullock cart. If it is nearer she is conducted by her two friends. The mother of the bridegroom or the mistress of the house welcomes and conducts her to her own room and gives her refreshments. The guests are treated to a feast after which they take leave of the host. The *Aruva* and ten married Coorgs of their nearest kin remain behind. The members of the family along with them assemble round the sacred lamp, when the *Aruva* gives some homely advice about the duties and privileges of a married Coorg. Hearing this the bridegroom grasps her right hand and goes with her towards the door; but as he steps outside she remains within. 'Her relations now form two lines in front of the door, and the *Aruva* of the bride says to the *Aruva* of the bridegroom, "you have desired Purakka from us for Mandanna. We have given her, and now ask you, has she any claim on Mandanna's property house and yard, field and jungle, gold and silver, if she becomes the wife". To this the bridegroom's *Aruva* replies, "Purakka has a lawful claim upon Mandanna's property".' This is repeated thrice, and as a typical pledge of possession like the *gatti jamma* fee on investment with land, the bridegroom's *Aruva* hands over to that of the bride's family three pebbles which he binds to the hem of her garment. The bridegroom then takes the bride by the hand and leads her out of the house. This act of possession constitutes the principal part of the wedding ceremony.

In acknowledgment and as a mark of respect he makes his obeisance to those assembled by touching their feet. The

young wife in a like manner to prove her willingness to share in the labours of the house, and be submissive to make *pani karti* fetches a pot of water from the well to the kitchen, and carries a basket of manure to the nearest field, and then returns to her room. The Aruva then takes the bridegroom and thenceforth so long as she remains in his house as wife, she bears a new name, but will always be called by a familiar name under the parental roof. The married daughter receives from her parents a certain dowry on her wedding day, consisting of jewels, clothes, furniture, a good bed, but thenceforth she has no claim on the family property.[1]

Polyandry.—Writers on Coorgs are unanimous in believing that polyandry once existed among the Coorgs as among the Nayars and the allied castes of Malabar. But now there is not a trace of it so far as I have investigated. Polygamy, widow marriage, and levirate are in vogue among them. Space and time forbid me to deal with them in detail as also the pre- and post-natal ceremonies of the Coorgs. They are treated at some length in my forthcoming volume on the Ethnology of Coorg.

Coorg family.—Closely connected with marriage is the family. The Coorg family is a joint one of the patriarchal type. It is the domicile of all the male relatives and their children belonging to one parental stock. Two or three generations, grandfather, grand-mother, their sons, daughters, daughters-in-law and their children numbering 20 to 60 or even more in some cases, all live and mess together. The labourers who were once their slaves belong to the family, depend on their mistress for food and orders. So long as there is peace and harmony, a Coorg family is a fine institution of the patriarchal type. There is not a single domestic affair of any importance which may not be undertaken without consent or knowledge of the senior member. He is expected to watch over the principal needs of the family and its members individually and check irregularities of all kinds by sound discipline. The nature and extent of his government may be gathered from the fact that married sons and their wives choose their residence under paternal roof to avoid the responsibility of a separate establishment. The senior female member is the queen of the household, and holds a corresponding position among the junior members and their wives as also among the daughters. The peace and harmony which once prevailed is marred by discord which is occasioned by the harsh regime of an imperious mother-in-law, by the jealousy and heartburnings of the married members or the material questions affecting the family income and individual claims. The senior member who is the *Karanavan* of the family has no easy

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[1] Richter, *Manual of Coorg*, pp. 132–135; Moegling, *Coorg Memoirs*, pp. 35–40.

position under these circumstances. The domestic life under normal circumstances is brightened up by the affection of the children for their parents and relatives and the little ones of whom are the pets of the family. The bearing of the young in the presence of the old is decorous, but the grown up members are generally not well guarded in the use of proper expressions in their conversations with juniors. It is presumed to be their privilege. The educated young men of these days exercise an influence for good in the moral tone of conversation, and show due respect to their brother's wives with whom no familiarities are allowed. The sleeping arrangements are made with judicious care. There is, however, a tendency at present among the discontented members to break up the ancestral family by a division of the family property among the members.

Property and its disposal.—The property of the Coorgs chiefly consists of the ancestral house and the land belonging to it which under the Rajas was held on a feudal tenure and on a light assessment, termed *Jamma Bhumi* or birthright land because it was inalienably vested in the family or house, and the British Government confirmed the settlement. Additional land was taken up by them on the normal *sugu* tenure, but in course of time Government allowed, to some extent, such *sugu* land to be converted into *Jama* land. Other lands they held as Jaghir and some lands were given for Government service as *umbi* land on a light assessment. During the last thirty years many houses have opened out coffee plantations on their own or Government lands or rented cardamom jungles. Thus the actual wealth of the Coorgs consists of landed property and their prosperity depends upon their exertions and means of cultivation; but imprudent enterprises and unexpected reverses have caused much embarrassment. Formerly all the members of a Coorg house lived together in the ancestral home or outfarm, *Koopa*, neither of which could be legally alienated or subdivided amongst the members of the family, all of whom worked together for the common good under the management of the *Yajaman* or *koraka*, and had their subsistence on the proceeds. Any surplus on the annual reckoning became the property of the house for providing incidental expenditure on the occasion of marriages, funerals, and other ceremonies as also for the purchase of new land in the interest of the family. If, however, an individual member *kaikara* by a salaried Government Officer or by coming into possession of money through marriage was enabled to enter upon private speculation without any aid from the ancestral house, established a new homestead he maintained his share in the proceeds as long as he contributed to the expenses of the family. This is the proper method of setting up a new house in the absence of male issue or by an unmarried man, woman or widow, in order to secure the inheritance of personal property or rights.

The social morality of the Coorgs is controlled by a Council of elders called *Thakka Mukhyastan* who are the moral censors and managers of social affairs without any magisterial power from the Government. The authority of the Village *takkas* extends over offences against social customs, non-attendance of public feasts and improper conduct during the same, drunkenness etc. The offender has to appear before the village elders at the *ambala*, an open council room on the village green, where the matter is discussed. The presiding *takkas* pronounce the sentence which may be ten rupees in extreme cases. In the event of refusal on the part of the offender, he may be excommunicated, when he may appeal to the *Nad* or District *Takkas*, and their decision is final. An outcast Coorg may be re-instated on payment of the fine. The influence of the official class, and the increasing knowledge of the people with the common law tend to subvert the authority of the *takkas* who to accommodate to the altered conditions relax the control and adjust themselves.[1]

Magico-religious beliefs.—The Coorgs are animists and have the demon and ancestor worship. They have been influenced by the Malayali, Tulu, Canarese, Brahmanical and Lingayat superstitions. The Malayalis have made themselves indispensable at their demon and ancestor worship. The Tulus have smuggled in their demons and their services are requisitioned as *pujaris*. The worship of Mari Amman (small-pox-demon) is introduced by the Mysoreans and the vows of people are made to them. The domiciled Brahmans of Coorg have succeeded in the introduction of the worship of Mahadeva, Subramania, and have temples erected and idols set up for worship. The Lingayats or Sivachars are also endeavouring to introduce their worship of Linga. Since the days of Dodda Virarajendra, Christianity was presented to the Coorgs, and there is a Roman Catholic settlement with a fine church at Virarajapet. But Christianity has not made sufficient progress in Coorg.[2]

Demon and ancestor worship.—The ancestral worship of the Coorgs is based on the belief that the spirits of the dead hover in and round their houses and give endless troubles in the absence of proper worship. For this purpose a *Kaymada* (handy building) close to the house with one apartment, or in some cases a *mire niche* built near the house, a *kota* or a raised platform under a tree in the fields where the original family's first house stood is constructed. A number of crude figures in silver or bronze or roughly carved images on slabs of pot-stones are placed to represent their ancestors, and sticks mounted with silver, knives or weapons are kept in memory of them. A male

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[1] Richter, *Ethnographical Compendium*, p. 41.

[2] *Ibid.*

ghost is called *Karana* and a female one a *Sodalachi* or *Karanachi.* It is a belief among the Coorgs and people of similar culture that these ghosts are ever troublesome, and females even more so. The *Sodalachis* are ever inclined to smite children with sickness and sometimes even the adult males and females of the house. In fact they are ever inclined to do harm. With a view to appease their wrath, rice, arrack, milk and other delicacies are offered on various occasions during the year to them. Once a month a fowl or two are decapitated at the *Kaymada* to please them. In such cases, a member of the community becomes possessed. He then puts off his head dress and walks in front of the house in a state of trance. While in this condition the members of the family appear before him to represent their grievances, cases of illness and the like. He makes some disjointed utterances which are believed as coming from one of the ancestors who has not been propitiated with offerings. At once he is treated to meat and drink. Neighbours also are allowed to come in and put questions to the possessed. These gifts are called *Karana Barana.*[1] Another performance is the *Karana Kola* which is a ghost-mask conducted with the object of finding out the particular wishes of the ghosts. It is performed every second or third year and occasionally also every year. For this a Malayan performer, a *Panikan* or *Benna* is requisitioned. At night he puts on one after another five or more different costumes to represent the number of ancestors especially remembered at the time. Arrayed in these costumes he dances to the accompaniment of a drum beaten by his companion and behaves as if possessed by the Coorg ghosts. After each *kola* or mask he leaves the house with a fowl, a cocoanut, fried rice and other eatables, some arrack and offers them in the courtyard to a particular ghost. When in a state of trance various questions are put to him by the members of the family as also by the neighbours. The food given by him is called *Karana Barane* mask having been finished, a pig is fattened especially for this purpose and is decapitated in front of the *Kaymada* either by the Malayan performer or by somebody of the family pointed out by him. Its head is placed for some time in the *Kaymada* and then taken back to be given to the performer. The rest of the carcase and the heads of the fowls decapitated are taken to the house. In the absence of a *Kaymada* attached to a house, the pig offering takes place at the *Karana Kotta.*

Women also behave likewise, when possessed by an ancestral spirit. While thus affected they roll on the ground, but they do not give utterance to oracular responses. Sometimes threats are sufficient to cast out the ghosts. Sometimes sorcerers, either

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[1] L. K. A. Iyer, *The Mysore Tribes and Castes,* Vol. I, p. 286, 291–294; Richter, *Ethnographical Compendium.*

Coorgs or aliens, are invited to exorcise the ghosts. With the recitation of certain formulæ in loud tones they resort to flagellation. If it proves ineffectual offerings (*bali*) are given.

Demon worship.—Male and female demons of Coorg are supposed to be more malignant than ancestral spirits, and are therefore very much dreaded. These demons are called *Kulis*, and one of their tricks is their carrying off the souls of the dying members in a family. Whenever any trouble arises in a house, and strange voices are believed to be heard in and near it, a Kaṇyan (a Malabar village astrologer) is consulted as to the cause of it, and he invariably speaks of the mischief of some *Kuli* who must have carried away the soul of somebody either in the house or in the neighbourhood. A demon-mask, he suggests, must be performed for the liberation of the soul. It takes place once a year at *Kutta*, and at other places once in two or three years. The master of the house ties some money in a piece of cloth which is suspended from a rafter of the roof of his house as a pledge for the performance of the ceremony. Sometimes he ties his brass plate up there and eats his food on a plantain leaf as a vow. For the demon-mask either a Malayan magician or a *Tulu Ajjala Palaya* is sent for, and the ceremony is performed in the courtyard of the house-owner. Demon-masks are performed in the name of one or two of the five demons, namely, Chamundi, Kallugutti, Panjuruli, Guliga and Goraga. The details of the ceremony are just the same as that described for the exorcism of the ancestral spirits. The food for the performer in trance is known as *kuli barani*. The liberation of the soul is thus effected. The demon that has committed the theft is begged to leave the soul free. In the event of his refusal, the performer throws a handful of rice on the member of the house standing near him, and thus transfers the spirit to him. The spirit alights on his back, when he falls in a swoon and is soon carried away by others into the house.[1]

Festivals.—The principal festival of the Coorgs and the Holeyas is the Harvest feast or Huttari, which occurs at full moon at the end of November or beginning of December, when the first fruit of rice, *Puttari*, is gathered and carried in procession to the house, the people shouting *Poli, Poli, Deva*, i.e., increase, increase, O God, followed by a blast of the shrill Coorg brass horn. It is truly a thanksgiving and a national feast and entirely unaffected by Brahmanism. It spreads over seven days and starting with village rejoicings it extends to *Nad* or district gatherings, every day finishing off with the peculiar cane dance of the men and boys to the most melancholy and monotonous sound of horns, drums and songs. Other games vary

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[1] L. K. A. Iyer, *The Mysore Tribes and Castes*, Vol. I, p. 294; Richter, *Ethnographical Compendium*.

the proceedings, but the most interesting part is always the champion fight in playful dance, which often ends in a general skirmish in which the canes are freely used.

Kaylmurta.—Another truly Coorg feast is the *Kaylmurta* which takes place some time in August when the hard labours of ploughing, sowing and transplanting of rice are over, and a break in the monsoon spreads its bright light and sunny warmth over the hills and valleys, forests and fields in Coorg and a holiday is most welcome. On the morning of the joyous day the whole armoury of the house is collected in the veranda, gun and spear, bow and arrow, broad sword and knife, and the young men sit down to burnish the familiar weapons. At the right moment, *muhurta* (auspicious moment), incense is burned before the weapons, piled up in the hall of the *Kanni-kombare*, sandalwood paste is dotted upon them in profusion, and a show-offering, *nivedya*, is offered to them and the idols. The ceremony is then finished off with a general meal. The men then proceed with their arms to the village-green, *uru-mandu*, to spend the afternoon in shooting at a mark and in athletic sports. The following day is devoted to a hunt in the forest belonging to the village, and on the day after a great hunt of the whole *Nad* is organized. Of whatever game is brought down the man who killed the animal receives a hind quarter and the head, the rest belonging to the company. To the taste of 'young Coorg' the *Kaylmurta* is the most glorious of all festivals, and the popular song of the Coorg mountaineer does full justice to this sentiment.

The Bhagabati worship which was originally a Coorg observance must have been brahmanized by the Tulu Brahmans. It is connected with demoniacal possessions and extends over nine days. Tantri Brahmins, Coorgs and Holeyas, each and all, have their share in the feast, and votaries disport their orgies in as wild and noisy a manner as the Ajjala Palyas. The chief object of the feast, however, is the collection of votive offerings for the Tantra Brahmins.

Grama Devatas.—The Grama Devatas (village gods), Ayappa, Kalyat, Ajjappa, Mariamma, Durga, Bhadra-Kali, have their annual feasts among the Coorgs as well as among the Holeyas; but they pay special attention to Ayappa, Kaliat Ajjappa and Kuttatamma in Kiggathan, whose shrine is annually visited with gifts.

The Coorgs go on pilgrimages to Irjatre at the foot of the Lakshmatirtha fall in Kiggatnad after Sivarathri in February or March, and to the *Tale-Kaveri-jatri* to the source of the Kaveri in October. Amongst the *jatres* beyond their own country those visited by the Coorgs are four: Subramanya on the northern frontier of Coorg in December, Baitur in Malabar in January, Payanur also in Malabar in February, and Nanjangodu in Mysore which comes off in December. As exceptional cases some of the Coorgs go also to Gokarna and Benares.

The Coorg Devastanas (houses of gods) are generally of rude village shrines of mud walls and thatched roofs within a gloomy grove. The only ones deserving some notice are those at Bhagamandala Palur, Irpu and the Omkaresvara Devastana at Mercara, the latter of which is built in the same moorish style as the Rajah's tombs.

Language.—After a careful study of the Coorg and Dravidian languages, Richter says that there is a close relationship between the Kodagu and the other Dravidian languages; but being neither cultivated beyond its colloquial use, nor possessing any original literature, it hardly deserves the distinction of being elevated into a special Dravidian language, as Bishop Caldwell does in his *Comparative Grammar of the Dravidian Languages.* It may correctly be noted as a mere local dialect.

Conclusion.—From the foregoing account of the Coorgs, it may be seen that they are an interesting and isolated community living on the mountainous tracts on the west coast of India. They are said to resemble the Scotch clans. Their racial history like that of the Todas is a puzzle to anthropologists. They are the products of their mountain habitat, climate, food and occupation. Hinduism has had no influence on them. Their traditional customs and manners are gradually changing in favour of western culture.

SECTION OF ANTHROPOLOGY

Abstracts

1. A comparative study of the Kulin and the Srotriya Brahmans of the Radhiya Brahman community of Bengal.

T. C. Roychaudhuri, Calcutta.

Somatometric measurements, of stature, head length, head breadth and head height, nose length, nose breadth, face length, face breadth, orbito-nasal diameter and orbito-nasal arc and the following indices—cephalic index, altitudinal index, nasal index, facial index and orbito-nasal index have been considered.

Besides these skin colour, eye colour and hair structure are also taken into consideration.

2. An enquiry into correlations between age and cephalic breadth; age and bizygomatic breadth; cephalic breadth and bizygomatic breadth of the people of Bengal.

Bhupendranath Datta, Calcutta.

3. Somatometry of the students of the Medical College, Vizagapatam.

R. Krishna Rao *and* A. Ananthanarayana Iyer.

The paper deals with the somatometric study of two hundred students representing mostly the intelligentsia of Andhradesa along with others, furnishing detailed anthropometric measurements and principal physical ethnic criteria such as skin colour, hair form and colour, eye form and colour, stature, weight, head form, nasal form, etc., usually employed for determination of racial affinities. The basis of classification are, age, sex, (all males) territorial and linguistic distribution, religion and caste.

The various indices have been calculated and graphs photoed for fixing and ascertaining mean and model type, regarding stature, cephalic index, nasal form and other characters.

The study reveals, that the model height as indicated by the peak of the graph is 1675 mm. (above the middle height according to Topinard's grouping) that the dominant head form is *mesaticephalic* with an average over 76 and that the mean nasal index is 73 (Platyrrhine type). Detailed descriptions and tabular statements of individual measurements are given in the body of the paper.

4. The Anthropology of Brahuis.

C. R. Roy.

Account based on the observations and anthropometric measurements of 100 individuals taken at Mohenjodaro (Sind) while working in the excavation—general description of the physical features—analysis of

the metric data—results of the combination of the cephalic and nasal indices—comparison with the other racial groups specially with the Dravidian owing to the similarity of language—abbreviation—details or measurements.

5. Megalithic culture of the Khasis.

DAVID ROY, Assam.

The whole idea behind the ceremonies performed at the stone erection is to mark by means of stone, the fact that the person does not die, and that his bones are collected and deposited. Stone in the Palæolithic age is the available material that shows signs of strength and permanence ; hence stones are erected, and in them we see the Khasi idea that permanence in life cannot be secured except in the connection between the living, and those who have passed over the border ; and the food giving ceremony (aibam) is continued for the dead, as Khasis believe that the dead influence the living in their life and property.

6. The Negrito element in Travancore.

L. A. KRISHNAN, Trivandrum.

Early observers suspected a Negrito strain in the aboriginal population of India. Its existence among the Kadars of the Cochin State has been several times referred to by Preuss, Sergi, and Haddon. The Uralis of Travancore seem to suggest the Negrito as much as the Kadar does. Occasional individuals with frizzly hair, low stature, and negro-like features are very suggestive of survival of the Negrito race. Quatrefages laid down that the Negritos are brachy-cephalic. Though the mean cephalic index of the Kadars was dolicho-cephalic.

7. Menstruation, childbirth, and marriage among the Kotas.

M. B. EMENEAU, Ootacamund.

A description of menstruation and childbirth observances among the Kotas of the Nilgiris, with marriage ceremonies as a pendent. Uncleanness at menstruation is contagious to the other women—ordinary men, diviners, and priests, in the ascending order of duration of the contagion. By seclusion and baths in successive stages—first in a seclusion house, then in a special house in the village, then in a woman's house. If the woman's period will fall within a festival, she undergoes a shortened purificatory rite in anticipation, and during menstruation she is regarded as ritually clean. The Kota view of menstruation is a legalistic one, rather than realistic. At the age of twelve and before menstruation a girl must go through a betrothal ceremony at the seclusion house. This is probably an initiation into menstrual observances to which a betrothal has been attached. At childbirth the first confinement is regarded as more polluting than succeeding ones. Anciently the seclusion period was between three and four months, during which no person could approach the woman. Confinements after the first (anciently after the second) involve the same seclusion as menstruation.

8. The caste changes in Indian history.

M. H. KRISHNA, Mysore.

Though caste is to all appearances static, history gives instances of families and castes rising or falling or getting inter-mixed with other castes. A survey of some of the chief Royal dynasties of the Deccan and their matrimonial connections prove this fact. For example, the Satavahanas were Brahmins who inter-married with the Sakas of Surastra.

The Kadambas were Brahmins who became Kshtriyas, the Vardhana dynasty of Kanuj were Vaisyas who became Kshtriyas; the Pallavas are said to have been originally either of Parsian or Kurumbar origin. There are traditions stating that the first dynasty of Vijayanager was of Kuruba origin and third one of Bhanta origin. These and other instances go to show that at least in the Royal dynasties, castes were flexible to a considerable extent.

9. Geography and sub-castes in Mysore.

M. H. Krishna, Mysore.

In the formation of sub-castes, geography played a considerable part in the past. The want of means of communication and the problem of distances often separated the castes into many sub-castes. This is proved by a study of some of the typical sub-castes of the Mysore State, for example, the Babburkammes, the Uruchukammes, the Siranadu Karnatakas, the Badagunadu Karnatakas, the Mandyam Iyengars, the Mardur Iyengars, the Malur Iyengars, the Hemmiga Iyengars, the Nonaba Vokkaligas, the Morasu Vokkaligas, the Gangadikar Vokkaligas, etc. Thus many sub-castes which are now endogamous were originally parts of a larger caste, which were separated from each other by geographical conditions and became separately crystallized.

10. The cultural pattern of the Tharus.

D. N. Majumdar, Lucknow.

Each culture has certain goals towards which the behaviour of the group is directed and which their institutions further. The discovery of fundamental attitudes rather than the functional relations of every culture is important as it explains how certain controls of emotion, certain ideals of conduct which actuate the behaviour of the individual account for the persistency of abnormal attitudes viewed from the standpoint of our civilization. An analysis of Tharu culture, with a view to find out the fundamental attitudes and ideals shows how in spite of changes in the contents of the culture, the configuration has a remarkable permanency.

11. The vagrant castes of the Kotah State.

R. P. Gondal, Lucknow.

The paper deals with the economic life and habits of a number of vagrant castes such as the Kanjars, Santias, Lohkutes. Most of the vagrant castes and tribes who wandered about with their females, children and all their belongings from place to place, some of them looting and stealing, others organizing regular bands and committing dacoities have completely taken to settled life. The beliefs and practices of these castes have been described and their cultural life explained. (The paper was illustrated by lantern slides).

12. Individual differences in Indian villages.

Amir Ali.

This study consists mainly of diagrammatic representations of individual family incomes grouped according to castes in five different villages, two in the Karnatak and three in Bengal.

The argument is that while we are inclined to treat the Indian villages as more or less one definite type, there are, on the contrary, an infinite number of differences even between villages of the same region. The diagram representing the contrasts between three adjacent villages in west Bengal and two nearby villages in Raichur indicate how economi-

cally and socially each of these villages presents an entirely different structure, and how the problem of rural reconstruction is really different in each case. It is suggested that economic and social researches in the villages should also be organized on a thoroughly scientific basis.

13. Comparative anthropometry of a group of Saoras of both sexes.

D. N. MAJUMDAR, Lucknow.

On the basis of measurements taken by the author last year of 125 Saoras of both sexes living in R. Udayagiri in the Ganjam Agency tracts, the author explains the probable race elements among the Saoras.

14. Women and social progress in India.

(MISS) THAKUR DAS, Lucknow.

The paper traces the growth of women's movement in India, the work of women societies, of women in public services, the professional status of women, their political status and training facilities for social service work.

15. Agricultural castes of Travancore.

K. C. N. GEORGE, Lucknow.

The paper deals with the social and economic life of some important agricultural tribes and castes of Travancore.

16. Marriage-classes among the Tarao Kukis of Assam.

J. K. BOSE, Calcutta.

The Taraos are linguistically classed as a branch of the old Kukis inhabiting the hilly region in the south-eastern portion of the Manipur State in Assam. At present they have only one village with twenty-eight families. According to earlier authorities they had four clans but our investigations *in situ* reveal that one of the four clans has merged into another. The cyclic system in marriage regulation which was recorded by earlier authorities is still present among them with some of the modifications due to the decreasing number of the tribal population. The mother's brother's daughter is the preferential mate and the father's sister's daughter is generally avoided—these facts were not recorded by the previous writers. A detailed discussion with diagrams is given in the paper.

17. Slavery in Kerala.

L. A. KRISHNAN, Trivandrum.

Slavery was formerly widely prevalent in Kerala. The Pulayans, the Parayans, the Malavetans, the Malankuravans, and the Pallans groaned under heavy disabilities. In 1792 the Honourable the East India Company issued a proclamation against dealing in slaves, but it continued till 1862 in some form when the penalties for slave dealing contained in the Penal Code inflicted the final blow to slavery in Malabar.

In 1812, 1853, and 1854, the Royal proclamations of the three rulers of Travancore formally abolished slavery in the State. The removal of other minor disabilities followed as a matter of course. The wholesome influence of these changes has awakened in them a new consciousness and stimulated in them a new desire to work for their salvation.

18. A note on Sema anthropometry.

SARABJIT SINGH, Imphal.

The paper deals with the physical characters of one hundred Semas from the Naga Hills. The measurements taken include stature, head length, head breadth, nasal height, nasal breadth, face height and face breadth. Average and indices are calculated from the crude figures.

Tradition states that the Semas are related to those of the Naga tribes who came out along with them from the Kezekenima stone. The present study is an attempt to compare them racially with some of those tribes and to find out how far their physical characters corroborate the tradition.

19. The Ao—Chongli and Mongshen.

SARABJIT SINGH, Imphal.

The Ao is divided into two distinct groups namely Chongli and Mongshen speaking different languages and having certain different customs. The cultural and social differences were studied in the monographs by Mr. J. P. Mills and Rev. W. Smith.

The author took some anthropometric measurements of the Aos during his tour to Mokokchung sub-division of the Naga Hills. In this paper the author compares the physical characters of the two groups, and attempts to find out their racial likeness according to the formulæ of Prof. Pearson.

20. The Metei calendar.

SARABJIT SINGH, Imphal.

In the Metic economical life, the annual calendar occupies a very important position. Every month has a special meaning attached to it and brings in some fresh work for them. The months in the year are twelve in number of which two are supposed to be rotten. The year begins with *Sajifu* with usual ceremonies, merrymaking and abstinence from work called *Silhenaba* for seven days.

21. Preparation of beer by the Loi-Manipuris of Sekami.

SARABJIT SINGH, Imphal.

Peculiarly enough among the Manipuri Hindus the Loi of Sengmai drink beer (yu) and manufacture it. To make it, yeast is prepared from husked rice. It is fermented and by a process of distillation; a very strong alcohol is prepared. The various processes in the brewing are described.

22. The social and economic organization of the Nulia fishermen of the east coast of India.

H. C. CHAKLADAR, Calcutta.

These fishermen live on the east coast from Konarak to Vizagapatam and a little further to the south. Each village has a chief and the head of the community is the Raja Mandasa near Waltair. The chief works through officers—the Kariji and Samitodu. They have a kind of cross-cousin marriage, and divorce can be obtained with or without reason for the payment of fine. The women enjoy considerable independence. Their worship is accompanied by dreadful bloody rites performed by priests of their own community, the chief deities being mother-goddesses (Satthis-saktis) though quieter. Brahmanic gods are gradually being included in the pantheon. There is good and sound economic organization for the catching and disposal of fish which they generally catch on the sea. They

have two sets of names for each of the fish and other sea-animals. Only the secret names which are generally euphemistic are used among themselves on the high seas. They have different names for even slight changes in the current or of aspect of the sea. The total catch of a favourable season goes up to a thousand rupees or more.

23. The material culture of the Rawaltas of Rawain.

S. D. BAHUGUNA *and* D. N. MAJUMDAR, Lucknow.

An account of the Rawain and the Rawaltas and their social organization. Their houses, village appearance, ornaments and decoration are described. Inventory of objects produced, their calendar of work, processes of production, agriculture, co-operative activities, division of labour, specialization, and economic magic are also discussed.

24 Some songs and dances of Rawain.

S. D. BAHUGUNA, Lucknow.

A number of songs typical of the life of the Rwaltas have been selected. Of peculiar interest are the Bajuband songs which are love songs in the form of a dialogue between lovers. It is sung either by two persons or parties of opposite sex especially in the neighbouring hills. Most of the songs are indecent viewed from the standpoint of our own cultural pattern. These dances are very popular. Even old people of 60 are found to participate in them. A description of the different forms of dances is given ending with the *ragini* where professional singers belonging to the low castes sing and dance to the accompaniment of music and move from field to field during the harvest season affording relaxation between periods of strenuous field-work.

25. Harvest festivals in Coorg and Malabar.

L. K. ANANTHA KRISHNA IYER, Palghat.

The festivals are socio-religious, and the customs connected with them are described. There are also points of similarities.

26. The anthropometry of the Santal of the Santal-Parganas of Chota-Nagpur.

P. C. BISWAS, Calcutta.

Hundred Santals were measured from the Daminikoh area of the Santal-Parganas where the Santal is living in a very pure state. The subjects were all adult male. It is worked out in the up-to-date method. A comparison with other Pre-Dravidian, Australian, and Veddas is also given. From that comparison I have arrived at the following conclusion that it is better to place the Santal within the Australoid Group. A full discussion of the Mongolian mixture with the Santal is also given.

SECTION OF AGRICULTURE

President :—Rao Bahadur B. Viswa Nath, F.I.C., F.N.I.

Presidential Address

SCIENCE AND PRACTICE OF AGRICULTURE IN INDIA

Ladies and Gentlemen,

I thank you for the great honour you have done me in asking me to preside over this year's session of the Agricultural Section of the Indian Science Congress. I am deeply conscious of the great responsibility that I have accepted and I trust that, with your assistance and indulgence, the proceedings of this session will be as successful as those of the previous years.

I have elected to speak to you on 'Science and Practice of Agriculture in India'. Fortunately, my task has been lightened inasmuch as my distinguished predecessor in this office last year discussed at great length the improvements effected and accepted by the cultivator and incorporated into the agricultural practices of the country, during the last quarter of a century. I shall, therefore, restrict my attention to the discussion of some of the more important experimental data in the light of agricultural practices and lay before you the problems as I see them.

Soils.

The work on soils has for its ultimate object the maintenance of the high productive capacity of soils which are rich, the restoration to normal those whose capacity has been reduced and to effect an appreciable increase in the yield of soils which are naturally poor. The attainment of these results is based on three fundamental factors in soil management. These are, (1) adequate pore space in the soil not only in the portion turned over by the plough but throughout the effective root zone and within and between the soil crumbs, (2) the existence in the soil of a large amount of plant food constituents not in available forms but *in reserve* and which, by proper soil management, are transformed into an available state, sufficiently rapidly to meet the requirements of crop, and (3) good tilth and ample crumb structure throughout the root zone which bad management breaks down and good management builds up and maintains.

The important and common characteristics of the majority of the soils are that they are old, have reached a stage of minimum

cropping capacity, are subject to intense sunlight and extremes of temperatures and are alkaline in reaction.

Soil work in the beginning was, as would be expected, confined to problems of soil fertility. In recent years, the scientific study of the soil has received considerable attention. The work and experience of over a quarter of a century have brought into prominence certain factors which are of special interest. In the majority of cases, the characteristics and reactions of soils are determined more by climatic factors than by geological origin. For example, the so-called black cotton soils, though of different geological origin, have several important soil characteristics in common. The soil profile does not appear to have the significance that it has elsewhere, probably due to age and to the fact that the majority are transported soils. In several cases, the surface horizons are missing, due probably to erosion through centuries. The profile study is, however, of considerable importance in the field study of the soil as a whole. Such a study has been able to solve the puzzle in regard to the downward movement of water in stiff black cotton soils. It has been ascertained that minute cracks are responsible for the downward and lateral movements of water.

Soil-Cultivation.—The cultivation of the soil both in regard to its science and practice would repay careful study. Consider for instance surface cultivation. We were taught in the olden days that surface cultivation helps to decrease evaporation and on this basis the better growth of crop in cultivated fields was explained. Recent research has shown that surface cultivation does not help to conserve moisture, but does not explain its effect on crop growth. Likewise, the object of deeper cultivation was stated to be better aeration of soils. Leather's work shows that gaseous exchange occurs in soils normally to a depth of one foot. The effects of cultivation must, therefore, be looked for elsewhere. One accepted advantage of cultivation is that it contributes to tilth and crumb structure in soils. The satisfactory formation of soil crumbs due to the aggregation of smaller particles by cultivation depends on the stability of these aggregates towards water. The more stable they are, the better they will be from the point of view of crumb formation. In the light of modern work on soil clay, crumb formation and its stability depend on the cationic composition of the clay. It is greater and better for calcium clay than for other clays. The water relationships that exist between clay and water and the salt content of the soil and clay, exercise a direct or indirect influence according to conditions. The intermediate stages between complete calcium clay and sodium clay may have varying degrees of moisture requirements for the use of the plough. The usual studies relating to plastic flow and other characteristics of soil are not correlated with the moisture levels at which the farmer would plough. This is probably because

of the aggregation of particles under the intense heat of the sun and the effect of salt concentration due to evaporation. The more we understand these factors under different conditions of climate and cropping, the better we shall be in a position to deal with problems of soil cultivation.

There is evidence that frequent and deep cultivation is harmful to the soil and to the crop. This is in opposition to what we have been taught but is in agreement with the practice of the cultivator who, except at great intervals of time, does not ordinarily cultivate his soils deeply, nor is he willing to carry out too frequent cultivations of the surface soil. At Hagari in the dry farming tract of the Bellary district, cultivation of black soils to a depth of eight inches every year with a view to conserve moisture was distinctly harmful to crop, while, when it was done once in five years, it was distinctly beneficial to both cotton and jowar. On the other hand, in the shallow soils of Bombay, Deccan, deep cultivation appears to be beneficial. On the west coast of peninsular India it is the general practice to plough light paddy soils with excellent results, but the same practice in the heavy delta soils has proved a failure. Recent experience in England also has raised doubts whether deep cultivation or intensive cultivation is really and always good. In an experiment in 1932 in England, neither potato nor sugar beet responded to more intensive cultivation than was necessary to keep down weeds. Indeed, further cultivation beyond this minimum amount did more harm than good.

Reference may be made in passing to what may be termed self cultivation of the soil, that is, the formation of aggregates of soil particles by alternate wetting and drying in intense summer heat. Not only does this process provide a more suitable water relationship, but it would also appear to induce beneficial bacterial activity and an increase in the water-soluble constituents, particularly of water-soluble calcium. It would be interesting to see what the effect of this will be on exchangeable bases. The rate of setting of colloids is also increased, due in part to de-hydration and in part to increased salt content. Those who have experience of paddy cultivation in heavy soils can readily realize the influence that this drying has on subsequent growth. The field study of soil aggregates under natural and artificial conditions of cultivation and cropping is likely to yield valuable information in regard to soil management.

Soil-Base Exchange and Related Phenomena.—Soil workers are familiar with base-exchange phenomena in soils. This is the greatest achievement of modern soil research which has brought about a revolution not only in the study of the soil, but also in the practical aspects of soil management and amelioration. The conception of the reactive soil particle and of its exchange processes as ionic interactions has given us valuable information in the study of our soils and in understanding their

behaviour, particularly in regard to irrigation and the formation and amelioration of alkaline soils. We now know how irrigation water and fertilizer salts can influence the composition and the properties of clay and the soil. We also know that in soils with adequate reserves of calcium, the intensive use of ammonium sulphate does not induce soil acidity. It is on the relative proportions of exchangeable calcium and hydrogen and not on their absolute quantities that the properties of a soil depend and by measuring the degree of saturation, it is possible to assess the field behaviour of a soil under irrigation or during the rainy season. Attempts to correlate base exchange capacity with crop performance are not yet successful.

It would be interesting to examine the applicability of deductions from base exchange studies to soils of arid or semi-arid nature. In this case, concentrations in the clay complex are likely to influence the processes of base exchange to a great extent. While with irrigation or rain the concentration tends to be lower, in the dry seasons it tends to increase and the exchange values are likely to vary with moisture content.

The composition of the clay complex with respect to cations is of primary importance in determining the soil's ability to absorb water. When saturated with different bases, the moisture holding capacity varies with the base in the descending order, Na. Ca. Mg. and K. The ability to part with water will be in the reverse direction.

The implications of these observations in experiments dealing with water requirements of crops or in the amelioration of alkaline and saline soils is obvious. In the case of the former, the critical and total water requirements of crops will vary even if every other variant except the soil is kept constant. Depending on the nature and quantities of the salts present the amount of water that will be available to the plant will vary. In a salty soil, maize and jowar wilted at over 12 per cent. moisture content in the soil, while in a salt free soil the wilting point under identical conditions was at 7·6 per cent. moisture. In the presence of about 2 per cent. organic matter on the weight of the soil, the position was considerably altered. The difference in moisture content at the wilting point in the two soils was narrowed down to below 1·5 per cent.

The swing of the soil's reaction depends on the degree of moisture in the soil. With soils above pH 7 alkalinity will be in evidence under wet conditions while under dry conditions the same soil will show diminished alkalinity and increased salinity. From theoretical considerations any calcium salt would be able to effect the necessary exchange reaction but in practice cost decides what should be used. In any case, the presence of organic matter is necessary. From these considerations molasses mixed with any available calcium compound is capable of bringing about the necessary reactions.

Fertilizers and Manures.

Considerable amount of work has been done with manures and fertilizers and we are now in a position to offer sound advice on their use. We must, however, know more in regard to the mechanism of their action particularly under arid and semi-arid conditions.

The Imperial Council of Agricultural Research has recently collected and collated all the available data on fertilizer and manurial experiments carried out in India in the past. The study of the data on experiments which are sufficiently comprehensive and long enough to justify the view that the results are truly representative, warrants certain broad conclusions. The evidence establishes the suitability and, therefore, the importance to the great majority of Indian soils of indigenous organic manures like cattle manures, green manures, bone manure and fish manure and oil-cakes; artificial fertilizers are of importance, but only of secondary importance by themselves, and they show themselves at their best in conjunction with organic manures or when the soil is normally rich in organic matter. In areas of precarious rainfall or inadequate irrigation facilities, artificial fertilizers almost invariably failed to be useful while the effect of organic manures was erratic. With assured moisture supply in the soil, the performance of artificial fertilizers was distinctly better and, in many instances, as good as and sometimes even better than organic manures, according to the nature of the crop.

Among the fertilizers the returns were greatest generally with nitrogenous fertilizers in almost all parts of India. The action of phosphates was evident generally but it was considerable in the crystalline tracts of peninsular India. The response to potassic fertilizers was not appreciable. Of the nitrogenous fertilizers, ammonium sulphate was the most satisfactory but not to such an extent as to rule out concentrated organic manures like oil-cakes, fish manures and hoof-meal. Superphosphates and ammonium phosphates showed themselves to be useful phosphatic fertilizers in combination with organic or inorganic nitrogenous fertilizers. Superphosphate was generally as efficacious or was even superior in some instances to bone meal, but when used alone the action of superphosphate was erratic. Potassic fertilizers were not used to the same extent as nitrogenous and phosphatic fertilizers. On the few occasions on which they were used, the response was either feeble or none at all, and this experience was perhaps a sufficient deterrent.

In several cases, the continued use of artificial fertilizers only led to bad residual effects on the soil. When used in combination with organic manures, however, the effect of artificial fertilizers was almost the reverse of that when used alone. Higher dosages did result in higher yields, but these were not

commensurate with the expense incurred. The evidence in regard to the time of application of fertilizers is neither extensive nor conclusive. What little there is, indicates that the fertilizers are best applied generally in one application at the time of planting for crops other than sugarcane, which prefers applications in two instalments. The next line of investigation should be of experiment and research on the internal and external effects of time of application to the crop. We have as yet not enough data on the proportionalities of N, P, and K, suited to different soils and crops and of the proportions in which organic and inorganic manures should be used.

The average nitrogen content of Indian soils is 0·05 per cent. and of organic carbon content is 0·6 per cent. Similar figures for European soils are 0·15 per cent. nitrogen and 3 per cent. organic carbon. European soils are five times as rich in humus contents and still the demand there is for organic matter. This explains the disappointing nature of fertilizer experiments on Indian soils. The needs of Indian soils are evident and the data from manurial experiments portray the requirements correctly. Cattle manure, green manures and other organic manures are valuable to soils because they supply what is popularly known as humus which is so essential to maintain soil fertility. The cry for organic manures for Indian soils is even stronger and more imperative because the disruption of organic matter is faster at the high temperatures obtaining in India. The rate of destruction can be imagined when it is stated that a soil receiving cattle manure at 10 tons per annum in two instalments continuously for over 20 years, contains only 0·74 per cent. of organic carbon as against 0·59 per cent. of organic carbon in a soil that received no organic manure at all.

The theoretical possibilities of artificial fertilizers are almost limitless, but their achievement on the majority of Indian soils is limited by climatic factors and economic considerations. In India the major part of its agriculture depends on the monsoon, and therefore the supply of moisture in the soil is the foremost limiting factor in production. The control of monsoon is beyond our power, but surely we can better conserve and regulate moisture in soils by husbanding the existing resources of indigenous organic manures and using them properly.

Organic Manures.—Work on soil organic matter is conspicuous by its absence. The reason for this is that the majority of Indian soils are notoriously poor in organic matter or humus. We are now concerned more with putting organic matter in soils, and when this is done, the other investigations will follow as a matter of course. All that we now know is that 70 to 80 per cent. of organic carbon put into the soil is oxidized in the first year and that the oxidation of pentosans is the most rapid.

Soil organic matter is the life of the soil. It improves the physical condition of the soil; it provides organic colloidal material

which plays a very important part in absorption and exchange. Its value in this respect can be realized when it is said that organic colloids possess four to five times the exchange capacity of inorganic colloids in the soil. It exercises a subtle buffer action and regulates soil reaction within limits. It increases the micro-organic population in the soil. It also increases the solubility of some of the soil constituents and assists in the more efficient absorption and assimilation of nutrients by plants. The problem of organic manures is therefore of fundamental interest to Indian agriculture. Time was when it was supposed that artificial fertilizers had substituted and would continue to substitute natural organic manures, especially farmyard manure, with equal and even greater efficiency. It is now universally recognized that organic manures, exemplified by cattle manure, are necessary for maintaining soil fertility and that no combination of artificial fertilizers can exercise the steadying effect on crop yields from year to year. It is in the experience of many that at first artificial fertilizers actually give larger yields than organic manures, but later this superiority is not maintained and falls off. Farmyard manure, on the other hand, though less effective in the beginning, is ultimately more effective.

The effect of farmyard manure is seen not only in the total crop yield but also in the higher ratio of grain to straw compared to artificials. In regard to the composition of the crop, there is no significant variation in nitrogen and potash but striking difference is noticed in the phosphate content of the crop from mineral and organic manured plots.

The most striking difference is in the quality of grain as *seed* and food. Ten years ago attention was called by Viswa Nath and Suryanarayana, and McCarrison and Viswa Nath to this important and till then unsuspected aspect of manuring crops. It will be instructive and useful to examine the evidence that has accumulated in this regard since then and to define the position as it now stands. With your indulgence I propose to discuss the work in a little more detail than it has been possible to discuss other lines of activity.

It is interesting to note that although the mechanism of action and the agents responsible for it are under debate, the evidence in the main lends support to the earlier observations on the effect of manurial and fertilizer treatment given to the crop. Repeated experiments by Viswa Nath, subsequent to the first publication, confirm the previous findings in showing that the crop producing quality of the *seed* is influenced by manurial treatment. When seeds from differently manured plots are sown in a soil of moderate fertility the resulting crops are different. The seed from a plot continuously manured with cattle manure gives a better crop than that manured continuously with artificials or not manured at all. Kruger (Landw. Jahrb., 1927) observed that the quality of *seed* potatoes is distinctly

influenced by manurial treatment. Kottmeier (Kuhn. Archiv., 1927) carried out trials to determine the effect of different fertilizers on the *seed* value of potatoes and found that the worst quality *seed* was obtained with physiologically alkaline fertilizers like calcium cyanamide and sodium and potassic manures, while the best all round effects were obtained with farmyard manure or physiologically acid fertilizers like ammonium sulphate. Tallarico (Mem. R. Accad. Ital., 1931) has found that seeds from plants that are over nourished have less vitality than seeds from poor soils.

The observation that manuring alters the vitality of the seed in the generation that immediately follows is considered by some as being antagonistic to the views on heredity in plants. A little reflection shows that it is not so. In effect it is equivalent to seed selection from a standing crop which is the recognized practice of agricultural botanists. It should be remembered that the yield of a pure strain of seed is capable of being influenced by soil conditions and treatment and this acquired character may continue, perhaps to a lesser degree, into the next generation.

Animal nutrition experiments by McCarrison with the identical grains (millet and wheat) as were used by Viswa Nath and Suryanarayana for vegetation tests, showed that grains grown with cattle manure possessed better nutritive value than crops grown with chemical manure or with no manure and that the crop grown with chemical fertilizers was superior to that from an unmanured soil. Viswa Nath subsequently carried out experiments with rats fed on grains and with rabbits fed on cereal herbage and with silk worms fed on castor leaves. The results were similar in all cases and those with eri silk worms is striking in showing that the effect of nutrition is carried to subsequent generations. *Pennisetum Typhoideum* was however an exception. Why it was so it is not yet clear. Rolands and Wilkinson (Biochem. J., 1930) tested seeds from grass plots manured with dung and with artificial fertilizers and confirmed McCarrison's observations in regard to the better nutritive value of produce from cattle manured plots. Tallarico (Atti. Akad. Lincei, 1931) fed birds (Turkeys) with grain raised on land fertilized with cattle manure as well as grain from land treated with mineral fertilizers, and found that those fed on grains raised with cattle manure showed more resistance to disease and those that contracted the disease were less seriously affected, their recovery was more rapid and the proportion of fatal cases less than in those fed with grains from mineral manured plots. Harris (Jour. Agric. Sci., 1934) tested wheat from differently manured plots at Rothamsted. His tests were concerned with the relative vitamin B_1 values, using the heart-rate technique and the results in terms of vitamin B_1 potency are as below :—

Plot and Treatment.	*Vitamin B_1 activity.*
Plot 3, no manure .. } Plot 2*b*, 14 tons of dung per acre .. }	100
Plot 5, complete artificial fertilizers, N plus K plus P.	80
Plot 7, complete artificial fertilizers + 412 pounds of sulphate of ammonia per acre. } Plot 10, 412 lbs. of sulphate of ammonia per acre. }	120

He concluded that there was a somewhat larger amount of vitamin B_1 in the specimens of wholemeal wheat flour from the plots which had been treated with ammonium sulphate and that the difference was not of a striking order. The period of his experiments lasted for four to eight days only, while usually in the Indian experiments at least 14 days were required for the appearance of the initial effect of feeding when the standard technique of growth tests on rats was used. A detailed scrutiny of these results is not possible as the treatments have been bracketed and only averages are given. Even so, the differences between the values for plots receiving artificials only are difficult to explain. It should, however, be noted that the test is mainly for vitamin B_1 activity which is different from general nutritive value.

The probable causes for the superior effect of organic manures may well be either in the relatively high vitamin contents of the produce, or in the better metabolism in the crop under better moisture conditions due to manure. In some experiments with herbage, Viswa Nath (Annual Report, 1930-31) found that the digestive co-efficients varied with the nature of manuring, herbage raised with cattle manure had a protein digestion co-efficient of 74 per cent., while the figures for the crops raised with mineral manure and no manure were 70 per cent. and 62 per cent. respectively. The animals were fed on equivalent protein basis. Cattle manured herbage had the lowest total nitrogen and soluble ash content. The quantitative effects of nitrogen and mineral contents of the feeds having thus been ruled out, the high protein digestibility of cattle manured herbage points to better availability of proteins and other constituents. In certain preliminary experiments, grain from the unmanured plot yielded the largest quantity of prolamin and that from cattle manured plot yielded the least. The values for the grain in the mineral manured plot have been intermediate. Similar proportionalities have been observed by Bishop whose findings are that low nitrogen content of grain is associated with low prolamin and high salt soluble protein content. It would appear possible that protein metabolism in the plant varied with manurial treatment. It is also possible that the

effect of cattle manure and other organic manures lies, in the case of the majority of Indian soils, in maintaining an all-round satisfactory condition, particularly with reference to moisture, for the normal growth of the plant.

It would thus appear that if we neglect organic manures and fail to build up the humus content of the soils we shall be doing four things.

Firstly, we shall not be able to maintain the fertility of the soil.

Secondly, we shall not be using artificial fertilizers to the best advantage.

Thirdly, we shall be failing to keep up the inherent cropping power of our improved seed and run counter to the good work of the plant breeder.

Fourthly, we shall be producing food deficient in nutritive value.

Whatever may be the present view and whatever future research may show in regard to the direct and indirect effect of manures and fertilizers on crop growth and nutrition and whatever may be the mechanism that influences the growth, the vitality and the nutritive value of the crop, it is clear that the effect of increased organic matter supply to the soil can only be for the good of the soil, the plant and the animal, including human beings. It is therefore justifiable to expect a unanimous acceptance of the proposition that at the back of all improvement lies that of the soil whose organic matter content should be built up by all means in our power.

The Nitrogen Cycle.

Soil nitrogen in its several phases has been receiving attention in many laboratories. The results of recent work bring into review the whole of the nitrogen cycle both from the scientific and practical points of view. Dhar and his collaborators have made the important observation and brought forward evidence to show that photonitrification occurs in soils. Their statement that it is partly micro-biological and partly photo-chemical has developed two schools holding opposing views: one favouring the older view and the other the new view. A critical examination of the results and arguments advanced by the two schools shows that the problem should, in the first instance, be narrowed down to the methods of analysis employed and that the two schools should carry out experiments under exactly defined identical conditions.

An important point on which there is unanimity of opinion is in regard to photo-denitrification. A consideration of this and the available evidence from recent work on soil nitrogen in India would appear to warrant a critical examination of the

significance of the process of nitrification and of the problem of the addition of nitrogenous fertilizers to the soil.

There is now a considerable volume of evidence in India and elsewhere that loss of nitrogen occurs from the soil in ways other than through drainage and the consensus of opinion is that the loss occurs in the form of elemental nitrogen under dry and swampy conditions. In a controlled pot-culture test the balance sheet showed that 30 per cent. of nitrogen added as sodium nitrate could not be accounted for. In comparative experiments in the field the loss was the greatest with ammonium sulphate, least with cattle manure and intermediate with green manure. The loss was, however, not a continuous process. It was a series of periodical gains and losses of varying degrees of intensity, depending on the nature of the material. The position in the end was that a nett loss in total nitrogen was registered with ammonium sulphate, and a nett gain with cattle and green manure, the gain being greater with the former. The presence or absence of crop did not make any difference in the nature of the reaction although there was difference in the magnitude of the fluctuation.

Nitrogen fluctuations in the soil are usually explained in terms of the effect of carbon-nitrogen ratios on the biological processes which begin to operate immediately the requisite nitrogen is either put in the soil or is obtained from the atmosphere and any defect in nitrate nitrogen is placed to the credit of the micro-organisms concerned. On this basis it is difficult to explain the loss of total nitrogen. The nitrogen loss appears to coincide with peak values for nitrate accumulation. The influence of carbon-nitrogen ratio might have been felt in the early stages of the process, but it is not clear how the loss in total nitrogen which appears to have occurred chiefly in the end product stage, can be connected with the carbon-nitrogen ratio.

Some recent laboratory investigations with soil cultures using sugar only in one set and nitrate only in another and a third in which sugar and nitrate are used together, show that regardless of the initial C : N ratio, the loss of carbon is fairly constant amounting to about 70 to 80 per cent. of added carbon, the ratio ultimately assuming a value round about 10. With sugar alone, loss of carbon was associated with gain in nitrogen, the latter obviously being obtained by fixation from the atmosphere till the ratio reached 10. With only nitrate the changes in the carbon and nitrogen were too small to be significant. When, however, sodium nitrate was substituted by ammonium sulphate, it was converted into nitrate with a loss of ten per cent. on the total nitrogen. Under field conditions there would be slow decomposition of nitrate in the presence of sunlight first into nitrite and then at an accelerated rate into the gaseous form. The addition of nitrate along with sugar resulted, as usual, in the partial loss of total nitrogen.

What is the meaning of all these changes ? What is the significance of nitrification ? If crops feed in the form of nitrates, why should there be loss of nitrate and nitrogen ? Is it possible that the capacity for nitrification is simply an index of the soil's respiration efficiency and the C : N ratio is a measure of that efficiency ? What is the relationship between nitrification and nitrogen fixation ? Can it be that nitrogen fixation is more intimately connected with the direct feeding of crop and nitrification is a means of rendering oxygen available, and what part does sunlight play in this ? Do the results of recent experiments by Subrahmanyan on the action of inorganic oxidizing materials give any clue ? These are all intensely interesting questions that arise from a critical study of the recent results and require an answer.

Meanwhile we may examine the problem with reference to practice. Nitrogen is the most expensive of the fertilizer constituents to buy. It is surely bad business if it is to be bought and put into the soil only to be entirely or partly lost into the air. Fortunately, however, it is capable of replacement in the soil by natural means. This recuperative effect of the natural processes in the soil, in restoring the combined nitrogen annually removed in the crops, has been receiving attention in several laboratories of the agricultural stations in India. Comprehensive studies on the nitrogen balance in the soil by Rao Bahadur Sahasrabudhe, in the field and in the laboratory, establish that considerable nitrogen fixation occurs sufficient to maintain the fertility of the soils of the arid and semi-arid tracts in the Deccan. A small amount of organic matter is essential for the optimum efficiency of the fixation process. Joshi has computed from field experiments at Pusa that under favourable conditions as much as 360 pounds of nitrogen per acre, including that removed in the crops, is gained in the cold and hot seasons.

It is natural to enquire that if such large nitrogen gains are possible, where then is the necessity for adding nitrogenous fertilizers and how additional crop responses are possible on the mere addition of 20 or 30 pounds of artificial nitrogen. If the conditions in the majority of Indian soils are favourable for nitrogen recuperation, the same conditions, namely sunlight and temperature, are equally capable of developing physical conditions unfavourable either for nitrogen conservation or for crop growth. The organic matter or humus of the soil is apt to be destroyed rapidly leading to a disturbed physical condition in the soil soon to be followed by all other inevitable consequences. Under such circumstances the addition of small amounts of artificial nitrogen probably helps, partly at least, in assisting the recovery of physical and biochemical conditions. The natural process of nitrogen recuperation depends for its success on the sufficient supply of organic matter in the soil.

Recent experience at the Kansas Experiment Station in

America is similar to what has been said above. At that station the greatest loss of nitrogen occurred with those tillage implements which caused the largest amount of nitrate development. The relationship between nitrogen loss and nitrate development in the first period was quite definite. Carbon losses were on the whole greater for the early tillage implements than for the late. Correlation of carbon losses with total nitrogen losses were not as close as in the case of nitrogen loss and nitrate development.

Attention may be drawn in passing to the recent communication that appeared in '*Nature*' of the 7th November, 1936, which records elemental loss of nitrogen from the unicellular fresh water alga *Chlorella vulgaris* and from the leaves of daffodil. While feeding on inorganic nitrogen, these plants lost about half of the absorbed nitrogen, no such loss was observed when the plants were supplied with organic nitrogen.

The Problem of Organic Matter and Manure Supply.

It is evident from the foregoing discussion how important organic matter and organic manures are for the great majority of our soils. Soil organic matter or humus is not an imperishable substance but is one that is rapidly attacked and destroyed by processes partly chemical and partly bio-chemical. The two processes are strongly activated by ploughing, which increases aeration and thereby numerous oxidation processes, resulting in the formation of carbon dioxide and nitrogen. The addition of artificial fertilizers will further accelerate the processes of destruction. The introduction of high yielding varieties and intensive cultivation lead inevitably to further depletion. It is computed that under our conditions about 75 per cent. of the fresh organic matter added to the soil and about thirty per cent. of the stabilized humus are destroyed annually. The position calls for investigations on the means both for conserving organic matter that is already in the soil and for increasing our resources of organic manures.

By carefully storing the dung, urine, litter and other refuse material, it is possible to conserve this source of supply. The different methods of storage were investigated over a number of years at several centres and it has been found that by adopting the system in which the cattle themselves compact the manure and litter, the supplies of farmyard manure can be augmented by about fifty per cent. However carefully it is preserved and its quality improved, we cannot get enough of it to meet the requirements. Composting all waste vegetation is another means by which the supply of farmyard manure can be supplemented.

The problem of composting has been receiving considerable attention at the hands of agricultural workers in India. These endeavours have always been to develop a technique suitable

to Indian conditions. In the earlier days, it was laid down that the addition of soluble nitrogen to the extent of 1 to 2 per cent. was necessary. A long series of investigations have shown that such added nitrogen is lost. Loss of nitrogen is related to the loss in dry matter up to a certain limit although not always correlated. It is not appreciable till the dry matter loss goes above 15 per cent. of the original material. The changes in the details of the technique during the last few years are indicative that the process of composting is still open to further studies.

From comparative experiments with loose-box manures and compost, it would appear that it is the organic matter of the compost or of the manure that is more important than its nitrogen components. It would appear that loss of nitrogen does not seem to be an avoidable factor and that the loss again depends on the initial richness of the basic material used for the compost. It would also appear from a study of temperatures that the process is both chemical and biochemical consisting of a low temperature period of chemical oxidation and a high temperature period of biochemical oxidation. Both the processes proceed side by side, the one or the other being a predominant feature for the time being. The low temperature fermentation seems to be more in evidence after the high temperature fermentation is over and when the apparent stabilized stage is reached. It is possible that the reinforcing of these composts with nitrogen and phosphate at the end of the fermentation period is likely to render fertilizer usage more valuable than it is now. The various methods of composting have each their merits and demerits. While many of the methods proposed are workable on plantation basis, their suitability to the peasant cultivator is doubtful. If composting is to form a regular agricultural practice in India, it is necessary that efforts should be made to make the method simpler and cheaper than what it now is.

Composting can be done wherever possible in the agricultural area. In the areas of precarious rainfall, there is not vegetation which can be composted and what little there is, will have to be used up as fuel, by the farmer. The possibilities of utilizing the vegetation of forest areas for supplying cheap fuel in the shape of charcoal and compressed briquets of composted humus, without affecting the requirements of the forests themselves, is a problem worthy of investigation. Vageler has estimated that the yearly production of fresh organic matter in the primæval or rain forest at one hundred tons per acre as a cautious estimate. For the monsoon forest the estimate is about 20 tons to the acre. The problem is, how much can be spared for the plains. The problem should be viewed and considered on the analogy of irrigation by which waters from areas of plenty are carried to areas of scarcity.

The next item for consideration is that of green manures. The cultivator is aware of the benefit of green manure. Whenever possible he has been growing it. But his efforts are limited by considerations of irrigation supply and the circumstances that compel him to take a food or industrial crop instead of a green manure crop. What is required is an industrial green manure crop like indigo which can bring him direct financial return leaving the plant residue on the farm. According to James Morton (Chemistry and Industry, 1930) we had in India some 1,300,000 acres growing indigo plant, yielding some 22,000 tons a year of what is now known as standard indigo paste, valued at about £4,000,000 and employing, it is said, some 6,000,000 people. Unfortunately, artificial indigo and other blue dyes are such formidable competitors to the natural indigo that it appears to be beyond the possibility of human effort to restore indigo cultivation to its former position. Any endeavour in the direction of facilitating indigo cultivation will be greatly appreciated by the farmer.

Problems of Food and Nutrition.

The problems of food and nutrition are in the forefront, not only in India but all the world over. No apology is, therefore, needed for considering them briefly under the two heads, quantity and quality of production. The question of nutritive quality has already been considered in the foregoing pages and we have seen how soil conditions can influence the nutritive quality of crop, and the means by which suitable soil conditions can be maintained. In regard to the quantity of production, it may be conveniently examined on the basis of protein requirement which again may be conveniently considered in terms of nitrogen. If we arrive at the probable quantities of protein requirements and the amount of protein produced by way of food crops, we can form an idea whether the position is one of surplus or deficit. These calculations are admittedly not accurate estimates but they give us a picture of the position in regard to the production of food crops.

A. W. Flux, in his presidential address to the Royal Statistical Society (June, 1930) on 'Our food supply before and after war', fixed 86·5 grammes of protein per head per day for England. This is equivalent to 14 grammes of nitrogen per head per day. For India, I have assumed that the food requirements are lower and have taken an average of 75 grammes of protein consumption per head per day. This is equivalent to 12 grammes of nitrogen. On this basis, the annual requirement of nitrogen, necessary for feeding a population of 353 millions, works out to 1,522,312 tons of food nitrogen for the whole population or 9·66 pounds of nitrogen per head per year. From the 247,000,000 acres under cultivation with various food crops, a total of 1,071,138 tons of food nitrogen are available. Thus,

we are short by roughly 500,000 tons of food nitrogen. In other words, we are at present producing food sufficient for the proper feeding of only two-thirds of the population.

The supply of food has to be increased by increasing the outturn per acre and by bringing more land under cultivation. With high yielding strains of crops and suitable soil management, it should be possible to increase production sufficient to meet the needs. Our botanists can and are producing high yielding strains which, on the average, give 10 to 15 per cent. increase in yield. A quarter of a century of experimental work has demonstrated that by rational soil management and manuring a further increase of 10 to 15 per cent. can be expected. The results of recent sugar-cane growing competition under the auspices of the Maharashtra Chamber of Commerce, Bombay, show that large increases are not impossible. In these competitions, the Kalamb Sugar Factory harvested as much as 104·28 tons of cane to the acre. Several other factories recorded 80 to 100 tons of cane to the acre as against the normal average of about 40 tons to the acre.

Conclusion.

In this brief sketch I have endeavoured to draw attention to some of the outstanding problems, the solution of which intimately concerns agricultural practice. It is now thirty years since agricultural research and experiment began in India and we have every reason to be satisfied with the progress made in the science and practice of agriculture. Great as have been our achievements in the past, we have only laid the foundations for the future. The scientific study of the soil will doubtless enable improvements for the future as it has done for the past, but the utilization of this knowledge to the full will be in proportion to our ability to build up the reserves of organic matter in the soil.

Indian agriculture is one of great antiquity and many of the present-day practices are the outcome of experience through at least fifty centuries. The Royal Commission on Agriculture in India, after an extensive and careful study, have recorded that the system of agriculture and the agricultural practices in vogue, stand unchallenged by modern research. We are dealing here with soils and practices several centuries old. We have seen how intensive cultivation even in the comparatively infant soils of Europe and America is bringing about experience, which ten or fifteen years ago would have been incredible. The experience with frequent cultivation, the effect of organic matter and the cry for more of it are instances in point. The effect of intensive cultivation and the intensive use of fertilizers in India without the necessary accompaniments is obvious.

Time was when the Indian cultivator was considered

conservative, superstitious and unwilling to take advantage of improvements. Close contact with him has shown that he is neither of these and his reluctance is based more on common sense. He is quick to realize benefit where it lies and is quicker still to take advantage of it. His willing response to the various improvements suggested to him during the past quarter of a century is eloquent testimony to his readiness to take up any improvement suited to the conditions with which he is faced. It is true he is fatalistic, but what else can he be, depending as he does on the vagaries of monsoon ? It is this fatalism, and its concomitant spiritualism, that make him such a stable element of society. Research should concern itself more with details of existing practices than with the evolution of wholly new methods and should aim at building up on the existing system a state of agriculture to suit the condition of the soil and the resources of the cultivator.

The next few years will witness considerable developments in Indian agriculture. We have in His Excellency the Marquess of Linlithgow, a Viceroy and Governor-General who is intensely interested in agriculture and rural development and who is thoroughly acquainted with the problems. Two distinguished and acknowledged authorities in the science and practice of crop and animal husbandry, Sir John Russel and Dr. Wright, are touring India studying agricultural problems of to-day and to-morrow. In the light of the advice of the experts and under the inspiration and fostering care of His Excellency, the country will witness many developments for the benefit of agriculture and the beginnings of a new life in the village.

SECTION OF AGRICULTURE

Abstracts

Agricultural Meteorology

1. The prediction of minimum temperature on clear days from the maximum temperature and vapour pressure of the previous afternoon at a number of representative stations in India.

M. Narasimhan, Poona.

It is found that the minimum temperature is associated with the maximum temperature and the water vapour content of the air during the previous afternoon. This is to be expected because the cooling of the air layers near the ground during the clear nights decreases with increase in the water content of the atmosphere. Regression equations for 17 selected stations in India have been worked out. These are of the form—

$$N=A+BX+CV,$$

where N is the minimum temperature, X and V are the maximum temperature and the vapour pressure respectively of the previous afternoon, and A, B and C are constants which vary with the station.

On applying Dr. Normands' 'Performance test' to the results in the case of Calcutta, it is found that the equation fully satisfies this test.

These results are of great value in the prediction of abnormally cold temperatures during winter.

2. The importance of precision observations on the growth and yield of crops in studies on agricultural meteorology.

R. J. Kalamkar, Poona.

The paper briefly summarizes the work done in India and elsewhere on the subject of precision measurements of the growth and yield of crops. The estimates of yield obtained by this method in India at Poona and Karjat are also compared with the actual yields.

3. Frost prevention by using heaters.

K. M. Gadre, Poona.

The paper describes the modifying influence of heaters on the micro-climate of a vine-yard at Nasik. These experiments on the prevention of damage due to frosts during the cold season were performed during the last winter at Nasik with the co-operation of the Deputy Director of Agriculture there.

4. The occurrence of droughts in India.

V. Satagopan, Poona.

The whole of India is divided into 30 sub-divisions and rainfall departures from normal for various years over these areas are examined and the occurrences of droughts over other parts of the country. A study of such coincidences leads to some interesting results.

5. The intensity of the radiation from the sun and the sky received on a horizontal surface at Poona.

P. K. Raman, Poona.

Continuous records of the total intensity of the radiation coming from the sun and the sky have been obtained at the Central Agricultural Meteorological Observatory at Poona since 1934 with the help of a solarigraph obtained from Messrs. Kipp and Zonen. The present paper summarizes the results for a period of two years and discusses the mean diurnal and seasonal variations of the intensity of radiation at Poona. The influence of cloudiness is also discussed in a separate section.

6. Frequency of heat waves in India.

N. Rajagopalan, Poona.

Extremes of temperature have a harmful effect on the growth and yield of crops. From an analysis of past records of the maximum temperature at selected stations in India, charts showing the frequency of occasions when the temperature exceeded various limits have been prepared. These are discussed.

7. Effect of rainfall on the quality of Indian cottons.

R. S. Koshal *and* N. Ahmad, Bombay.

Data for the last 12 years on the quality of standard Indian cottons have been examined with a view to finding out (*a*) the secular change in quality, (*b*) influence of rainfall in explaining the annual variation. Fisher's method of fitting polynomials has been employed for the analysis of the weekly totals of rainfall every year. These provided six constants which specified the average and distribution of rainfall throughout the season. The secular trend in these constants as well as in the quality data were eliminated by fitting polynomials of the second degree, and on the residuals thus obtained the multiple regression equation was worked out.

The analyses of results have indicated that the effect of rainfall in different periods during the progress of the season is very different. For example, for Nandyal 14, Jaywant and Hagari 1 cotton it is found that an additional inch of rain above the average during the growing period is harmful, during the maturation period it is comparatively beneficial, while during the picking period it is extremely harmful. For C.A. 9, Verum 262, Surat and Gadag 8 cottons the growing period may be divided into two parts. In the first half additional rain is beneficial while in the second half it is definitely harmful.

The investigation is of special value to the farmer, especially in the case of those cottons which are partly rain-fed and partly irrigated—for it would be possible to predict the quality of cotton long before harvest, and the harmful effects of deficiency of rain could be remedied to a large extent by giving suitable irrigation at the proper time.

Soils—Physics and Physical Chemistry

8. Soils as desiccators.

L. A. Ramdas *and* M. S. Katti, Poona.

In a series of papers published during the last few years the present writers have shown that during the clear season the desiccated surface soil plays an important part in controlling the moisture content both of the air and soil layers near the surface of the ground. Moisture is lost by the soil surface by evaporation during the day, but most of the moisture so lost is regained from the atmosphere during the night by absorption. In the present paper, laboratory studies on the relative merits of different soils as drying agents have been investigated. It is shown that of all the soils in India the black cotton soil is the most efficient in this respect.

9. The annual variation of soil moisture in relation to rainfall.

L. A. Ramdas *and* K. M. Gadre, Poona.

The paper describes the weekly estimations of the moisture contents of the soil at different depths in a bare plot at Poona, during the different seasons of the year. The influence of rainfall and of evaporation from the soil on the seasonal variation of moisture in the soil layers is also discussed.

Soils—Chemistry

10. A preliminary account of the experiments carried out to test the effect of sunlight on the nitrification of ammonium sulphate and oil-cake in the soil.

D. V. Bal *and* R. S. Krishnamurty, Nagpur.

It was seen that when unsterilized soils containing optimum moisture and nitrogen in the form of either oil-cake or ammonium sulphate, were exposed to bright sunlight, there was no nitrate formation even after a period of ten weeks, although when similar soils were incubated in the dark, nitrification was found to be very active, and about eighty to hundred per cent. of the added nitrogen was nitrified in a period of four to eight weeks. When sterilized soils containing adequate moisture and oil-cake are incubated either in the dark or in bright sunlight there is no nitrate formation in either case even after a period of six weeks. When unsterilized soils containing adequate moisture and nitrogen are kept in sunlight, in jars which are made impervious to the sun's rays, nitrification proceeds in the usual manner, showing thereby that it is the direct sunlight which prohibits nitrification and not the high temperature that is attained by the soils when kept in the sun. This is also corroborated by the results obtained from soils containing adequate moisture and nitrogen and incubated in the dark at a temperature of 50°C.

From the results obtained it appears that the lack of nitrification in soils exposed to direct sunlight may either be due to the death or temporary inactivity of the nitrifying organisms caused by the action of the sun's rays. The results obtained show clearly that nitrates in ordinary arable soils are formed as a result of biological activity and not due to the effect of sunlight; the latter has actually been found to be detrimental to the process of nitrification.

11. Changes of nitrate and ammonia in paddy fields.

A. T. SEN, Dacca.

As soon as a paddy field becomes water-logged the little nitrate which is present in the soil disappears and does not re-appear until about the end of the water-logging period. Nitrification in the uncropped plot is greater than that in the corresponding cropped plot after harvest. Throughout the dry period following harvest some nitrate is always present in the soil, but its amount fluctuates with the type of soil investigated, without becoming large at any time. Since nitrate is completely absent in the submerged soil during the rice growing season, it is of no importance from the point of view of supply of nitrogen to rice.

On the other hand, there is rapid ammonification in the soil as soon as it is water-logged. When the soil begins to dry up there is loss of ammonia which is much greater than the corresponding gain in nitrate. In the cropped plots ammonification predominates until about six weeks from transplantation. Thereafter, the uptake of ammonia by the plant far exceeds the amount produced and in the next three-four weeks the ammonia status of the soil comes down to a very low level. Evidence has been obtained that during this period somr ammonia not absorbed by the plant is lost from the soil. If the rice plant at this stage is cut off or bodily removed there is at once a gain in the ammonia content of the soil. But the ammonia content comes down again with the end of the water-logging period as is observed in the case of the uncropped plot. Thereafter the ammonia content of both cropped and uncropped fields remains low until the next sowing season. It is tentatively suggested that the observed loss of ammonia in the cropped and uncropped fields takes place in the form of elemental nitrogen.

12. Nitrogen loss from soils and its retardation.

N. R. DHAR *and* S. K. MUKERJI, Allahabad.

Field trials show, that nitrification of ammonium sulphate is much quicker in plots receiving sunlight, than in those covered with wooden planks. Moreover, in the uncovered plots there is more nitrogen loss than in the covered ones. Thus with 277·2 kg. of nitrogen added as $(NH_4)_2SO_4$ per acre of land, the loss is 43·9% in the uncovered and 8·2% in the covered plot. Molasses appreciably decrease the velocity of nitrification of ammonium sulphate added to fields and also retards nitrogen loss. Thus with 277·2 kg. of nitrogen per acre of land, the loss is 43·9% without molasses and with molasses the loss is 17·9%. Carbonaceous substances like sugars, cellulose, fats, etc., not only conserve soil nitrogen by decreasing the velocity of nitrification and denitrification but also cause nitrogen fixation in the soil as well. An aqueous solution of ammonium nitrite containing 14·5 grams nitrogen per litre undergoes appreciable decomposition into gaseous nitrogen and water at 20° and 30° even in the dark. The total light from a tungsten filament lamp of 1,000 watt accelerates the thermal decomposition of ammonium nitrite. This observation explains why marked nitrogen loss has been observed in heavily manured fields at Rothamsted and other experimental stations.

13. The effect of manuring and cropping on the vertical distribution of phosphates in calcareous soils.

S. DAS, New Delhi.

Three-inch soil borings up to a depth of five feet were taken of some permanent manurial plots in calcareous soils at Pusa and also of an adjacent fallow plot. These soil sections were examined for their total phosphate and carbonate contents.

As a result of phosphate fertilization, the concentration of phosphate increases only in the surface nine inches of a calcareous soil. This indicates that phosphate remains mostly where it is placed in the soil.

Phosphate concentration in the different vertical soil layers of a calcareous soil varies inversely as the corresponding $CaCO_3$ concentration. This relation is not, however, uniform in character and has been discussed in the paper.

14. The effect of manuring and cropping on the vertical distribution of carbonates in Pusa calcareous soils.

S. DAS, New Delhi.

Three inches soil borings up to depth of five feet were taken from nine permanent manurial plots and an adjacent fallow plot in Pusa calcareous soils. There are two zones of maximum carbonate concentration with one of minimum concentration lying between them in every manured and cropped plot. Above them are two more zones of low and medium carbonate concentrations. The position as well as the area of these zones varies with the plots. In an uncultivated, unmanured and uncropped plot a gradual rise in carbonate concentration occurs from the surface downwards. The total $CaCO_3$ of these calcareous soils up to a depth of five feet remains practically constant and distributes itself in a characteristic way from layer to layer depending on the nature of the fertilizer treatment. There is a fairly direct proportionality between the carbonate content and the fineness of soil texture as typified by moisture equivalent. The reaction (pH) of calcareous soils is unaffected either by manuring or cropping owing to their dominant $CaCO_3$ content.

Soils—Microbiology

15. Comparison of bacterial activities of soil samples from Pusa plots in 1906 and 1935.

N. V. JOSHI, New Delhi.

Bacterial analysis of four samples of soil from Pusa fields taken in 1906 and stored in corked bottles and samples of soil taken from the same in 1935 was carried out. This showed that the number of bacteria was 16 to 50% less in the 1906 samples than in those of 1935 but the number of fungi were higher in the older than in the new ones.

Comparison of the kinds of bacterial activities:—Nitrifying organisms, azotobacter and other non-sporing bacteria were completely absent in the 1906 samples. Only the spore-forming organisms like *B. subtilis*, *B. mycoides* had survived, but these latter kept up carbon dioxide forming power and the ammonifying power and the urea splitting power of the samples to a level fairly equal to that of the 1935 samples.

Complete absence of the nitrifying organisms and azotobacters and other non-sporing organisms suggests that during the period of storage no contaminating organisms could have entered the soil.

Manures and Fertilizers

16. An investigation into the effect of green manuring alone and in combination with phosphatic fertilizers on the yield and phosphatic content of paddy.

D. V. BAL, Nagpur.

Application of nitrogen alone in the form of *sann* to light loamy soil locally known as *matasi*, gives a higher yield of paddy per acre than that

obtained in the case of unmanured plots, but application of *sann* in conjunction with phosphatic fertilizers gives a significantly higher yield than that obtained from the plots receiving *sann* alone. It is seen that the percentage of P_2O_5 in paddy seed is increased by applications of phosphatic fertilizers in conjunction with *sann*. Application of nitrogen alone in the form of *sann* reduces the percentage of P_2O_5 in the seed. It is important, therefore, both from the point of obtaining high yields and also from the point of nutrition that whenever nitrogenous fertilizers are applied to the paddy fields, an adequate quantity of phosphatic fertilizer should also be applied.

17. Compost as a top dressing to sugarcane in Malwa.

G. C. Tambe *and* B. Goswami, Indore.

Artificial manures are generally used as top dressings to sugarcane. Malwa cultivator is not yet accustomed to their use. With a view to ascertain whether artificial manures can be replaced by compost, a randomized replicated experiment was carried out at Indore in 1935. Two varieties, viz. Co. 213 and Co. 290 were top-dressed both at planting and tillering times with compost and a mixture of two grades of nicifos and potassium chloride either alone or in combination, applied at two rates. The experiment was carried out on new and old garden lands. There was no difference in both fields in the yields of stripped canes whether artificials or compost alone was applied. The higher rate of compost gave a higher degree Brix for the juice of Co. 290 on garden land than that due to higher rate of artificials. Except for this there was no difference between the degree Brix and the purity of juice of both the varieties in both the fields due to either compost or the artificials or their rates of application. In combination, however, the yields of Co. 213 further increased when the artificials preponderated and those of Co. 290 increased when the proportion of compost was greater in the mixture. The effect of these combinations on the Brix and the purity of the juice, however, varied according to variety and the type of land. In general practice, therefore, the lower rates of compost or artificials singly seem to be preferable and cheaper.

18. Efficiency of different methods of manuring wheat in Rajputana.

K. R. Joshi, T. C. Kale, *and* G. K. Sant, Indore.

Wheat is usually grown with cattle or green manure under well or tank irrigation in Rajputana. Cattle are frequently tethered in the open in wheat fields and their urine and droppings are directly utilized. Application of compost and artificials is yet an innovation. Quantitative yield tests were carried out in several centres in 1934 and 1935 to compare the response and economics of the different manuring methods.

When applied on equivalent nitrogen basis both compost and artificials yielded significantly higher quantities of grain and bhusa than all other treatments. Ploughing in both *sann* and *guara* either alone or in combination with other treatments did not affect grain yields. But straw yields were depressed by *guara*. Both grades of nicifos applied after green-manuring at one cwt. per acre increased the yields of grains and straw. Higher rate increased straw but not grain.

Comparing costs, cattle dung and farm residues were most economically utilized by making compost, the urine being best used directly by tethering cattle in fields. Nicifos was found profitable.

19. Response of rice plant to nitrogen-phosphoric acid fertilizer.

K. C. BANERJI, J. R. PAL, *and* S. S. BOSE, Calcutta.

With a view to obtain the optimum requirement of nitrogen and phosphoric acid in the case of rice cultivation under Western Bengal conditions, a pot culture experiment was designed in the Bankura Farm with 10 increasing doses of niciphos repeated six times in earthern-ware pots. The results show an increasing response for tiller, height of plants, yield of grain and straw but with regard to inflorescence, length and size of grain the manure was without any effect.

It was also noted that the time for the maximum tillering stage was appreciably retarded with increasing doses of manure and that the maximum number of tillers was attained between 50 and 59 days. The chemical analysis of the soil before and after experiments indicated that the addition of fertilizer made some of the non-available nitrogen of the soil available to the plant.

Crops—Husbandry

20. Improved cattle demand better fodder: Pusa oats to fulfil this need.

R. D. BOSE, Pusa.

The paper discusses oats as a possible source of fodder.

21. Sub-soil water level and crop security in U.P.

B. MUKERJI, Lucknow.

The extension of agriculture and the limited potentialities of surface irrigation have both led to greater utilization of the sub-soil water in U.P. for purposes of irrigation. Ever since the Ganges grid electricity scheme was completed the whole sub-soil reservoir is being commercially exploited by hydro-electric energy. This has raised grave apprehensions as to the stability of the sub-soil supply on account of the enormous volume of water that is being abstracted. The question is very important for the ultimate security of crop irrigation on the one hand and of the tax-payers' money on the other. Three expert enquiries have recently been carried out on this question. In this paper, the necessity of tube-well irrigation is at first explained. The size and extent of the sub-soil water are then discussed and the chances of its exhaustion through tube-well abstraction are dealt with in the light of the experts' reports. It is pointed out that on the data available there is no immediate risk of a sub-soil vacuum and there is no present danger to stability of agricultural cultivation in the United Provinces.

22. The spacing of desi cotton (Cawnpore 520) in Gang Canal colony, Bikaner State.

SHAMSHER SINGH *and* G. K. SANT, Indore.

Manured cotton is grown under irrigation on the arid clay loams of the newly opened Gang Canal Colony in the north of Bikaner State. Randomized replicated experiments in 1932 and 1933 indicated the most suitable sowing date and number of irrigations. Three tests—one in 1934 and two in 1935 were therefore carried out with Cwn. 520 to discover a suitable spacing both between rows and plant to plant. Two feet spaced-rows thinned to a plant to plant spacing of 9 feet always

yielded either more or equally to all other spacings. Whether the crop was sown in May or June and was irrigated heavily or moderately, the result was the same. It seems therefore that this spacing can be recommended under local conditions of cotton cultivation.

23. The problem of irrigating *rabi* crops in the Gang Canal colony, Bikaner State.

SHAMSHER SINGH *and* G. K. SANT, Indore.

For the cold weather crops available water supply is limited in the Gang Canal colony. Four complex experiments were therefore carried out in 1935 and 1936 to determine the optimum number of irrigations necessary for wheat, gram, linseed and *sarson* grown by the usual cultivators' method.

Significant increases in yields ceased to occur in 1935 when the number of irrigations was increased beyond the limit of four for wheat and gram and one for linseed. According to soil fertility these limits in 1936 were five to six for wheat, four to five for gram, two to four for linseed and two to six for *sarson*. The differences in the optimum number of waterings for the two years were due to absence of rain in 1936 during the *rabi* season. Suitable adjustments for *rabi* cropping are discussed in the light of farm economy, availability of water and the optimum number of irrigations for each crop.

24. A note on sowing cotton in experimental plots.

K. SAWHNEY, Parbhani (Deccan).

In comparative tests and crops grown for statistical study it is essential to obtain a uniform stand of plants. Also the rapid multiplication of limited quantities of ' selfed ' seed of individual plants needs good germination. At the Cotton Research Station, Parbhani, excellent results have been obtained by the use of a holing board fitted with a number of conical pegs of required size. Seed sown in holes made with such holing boards has uniformly given good germination even when the sowing was done at the rate of one seed per hole. A description of the holing board and the method of using it is given.

25. Crop cutting experiments in Raichur.

AMIR ALI, Raichur (Deccan).

This study of a carefully planned crop-cutting experiment on Jowar carried out in the vicinity of the Raichur Government Farm in 1934-35 shows how the experience gained might be applied to the larger problem of simplifying procedure of crop estimates wherever Revenue and Agricultural Departments exist.

26. Soil fertility and moisture relationships in relation to growth and yield of rain-grown cotton in Malwa.

P. M. SALVEKAR *and* G. K. SANT, Indore.

In 1935 soil moisture at different depths, and plant weights at different stages of growth of Malvi cotton together with the seed cotton from thirty random plants were determined in two fields differing in fertility. Up to the flowering stage the poor field maintained a higher moisture level than the rich one in one foot depth of the soil. The moisture gradually diminished afterwards, ultimately becoming the same for both the fields.

The stem and leaf weights and their ratios in the rich field were higher during the growing and flowering stages than in the poor one.

The weights of flowers, buds and unopened bolls did not differ between the two fields at any stage up to December. The yields of seed cotton per plant, however, were higher in the rich field and were found to be highly and positively correlated with the ratios of stems to leaves at growing stage.

The differences in this test between the two fields were in the quantity and nature of plant growth in the early stage and in the content of free water in the soil. After the flowering stage in both the fields the moisture and the plant growth were equal thus showing the existence of nutrition sufficient for the growth of Malvi cotton. In spite of this the plants in the poor field failed to secure sufficient nutrition in the early stages, resulting in the production of a lower proportion of stem to leaf weight than in the rich field, followed by a lower yield of *Kapas*. The probable significance of this is discussed.

Crops—Genetics

27. The inheritance of habit in *Saccharum spontaneum* L.

E. K. Janaki Ammal, Coimbatore.

The local Coimbatore form of *Saccharum spontaneum* which has been extensively used in the breeding of sugar-canes at Coimbatore was analyzed for habit. Approximately 25 per cent. of selfed seedlings were found to be 'sprawlers' like the 'E.C.C.' form of the Coimbatore *Saccharum spontaneum*, about 50 per cent. semi-erect like the parent, and 25 per cent. completely erect.

The local Coimbatore form is, therefore, heterozygous for the sprawling habit which is inherited as a simple monohybrid ratio. An analysis of 100 seedlings of a Dehra Dun *Saccharum spontaneum* also gave approximately the same ratio. The effect of this heterozygosity on hybrids between these types of *Saccharum spontaneum* is also shown.

28. Tetrasomic inheritance in two *Saccharum officinarum* × *Saccharum spontaneum* hybrids.

E. K. Janaki Ammal, Coimbatore.

An analysis of selfed seedling of Co. 205 (Vellai × *Saccharum spontaneum* local) and its back cross with *Saccharum spontaneum* showed that the ligular process which is inherited as a dominant character in interspecific Saccharum hybrids is segregated approximately in the ratio of 35 : 1 in F_2 seedlings and 5 : 1 in back crosses with the recessive parent. The latter ratio was also observed in back crosses of Kassoer (Black Cheribon (?) × *S. spontaneum* Glagah) with *Saccharum spontaneum* Glagah. The cytology of the hybrids and the back crosses is briefly presented and supports the genetical data.

29. The inheritance of height and duration in sorghum.

G. H. R. Ayyangar, M. A. S. Iyer, *and* A. K. Nambiar, Coimbatore.

The inheritance of the character composite 'short-early' and 'tall-late' in sorghum has been pursued and set down to be due to differences in internodal number and disposition in length. In the short group there are about 10 internodes with a uni-modal distribution in length from the base upwards. In the tall group there are about 17 internodes showing

a bi-modal disposition in length. A factor In_1 is responsible for the production of fewer internodes with a uni-modal distribution in length; in_1 gives rise to a greater number of internodes and a bi-modal distribution of their lengths. In_1 is a simple dominant to in_1. The 'absorbing influence' of crossing is manifested in 'shifts' that give in the short-early group taller and slightly later plants, conforming to the general grouping 'short-early'. The earheads of the 'tall-late' plants were heavier, had more whorls, and more branches in each whorl, than the earheads of the 'short-early' group. Factor In_1 was independent of D, the factor for pithy stalks.

30. Mysore cottons and their importance, Part IV. Is it possible to develop in 'desi' variety a strain through hybridization to replace American cottons?

RANGNATH RAO, Bangalore.

For the cotton trade there is a definite need for the long-stapled American cotton. The American cotton is however liable to the red leaf-blight disease. *Desi* cottons resist the disease but have the disability of short staple and low yield.

Since hybridization between the new and old world cottons is not possible, resort was made to crossing one of *local desi* cottons (Nadam, *G. obtusifolium*) with the big-bolled Garo hill cotton (*G. cernuum*).

Selections from this cross have been in progress, for the last 8 years and as a result, a strain, CN 86 has been evolved.

This strain has a ginning percentage of 33–35, and a staple of $\frac{7}{8}$ of an inch long.

The strain has now been grown on a five-acre block and has in the first picking yielded at the rate of 5 mds. per acre equal to the yield from American cottons.

Crops—Physiology

31. The effect of cations on living protoplasm of root hair of *Azolla pinnata*.

B. SEN, Calcutta.

The changes induced in living protoplasm of root hair of *Azolla pinnata* by isotonic solutions (pH 6.8–7) of chlorides of Na, K, (M/20) and Ba, Mg, Sr, and Ca (M/30) have been observed under the ultramicroscope and microphotographs taken. These solutions were made to come in contact with the protoplasm of the hair by (i) the usual micrurgy methods, i.e., microinjection of solution or by pricking with micro-needle hairs immersed in solution and (ii) the increased permeability method I have described elsewhere, i.e., by electrically stimulating with micro-electrode hairs immersed in solution. Both give similar results but (i) has the great advantage that it can be graded, measured and repeated accurately and also permits introduction of different solutions in turn into the same cell. Na and K produce new granules, negatively charged like the normal granules, which continue to show vigorous Brownian movements. The bivalent cations studied produce larger granules which soon flocculate into irregular pattern, but no reversal of electric charge of granules takes place. Ca and Sr show similar distinctive effect as regards type and mode of formation of granules. Investigation of the effect of anions and antagonism of ions by the increased permeability method is in progress. A darkground cinema film showing structure of living protoplasm and cataphoretic migration of colloidal particles of protoplasm will be demonstrated.

32. Studies on some aspects of the water-relations of the cotton plant. Part II.

T. EKAMBARAM *and* C. JAGANNATH RAO, Madras.

This is the second of the papers presenting tentative results of a physiological study 'On some aspects of the water-relations of the cotton plant' namely results of the effect of three different percentages of soil moisture—15, 20 and 30 per cent.—on certain economic characters. The strains of cotton studied are C.7 (karunganni—*Gossypium indicum*) and H.1 (Westerns—*G. herbaceum*) grown in 1934-35 as pot-cultures in the Presidency College, Madras. The following are the indications. Number of flowers and bolls per plant, date of appearance of the first flower, total number of ovules and seeds per plant, total capsule weight per plant, total kapas or seed-cotton weight per plant and the percentage of mature fibres follow the order of the moisture percentage of the soil. The case of position of the first fruiting branch node appears to be erratic while maturation period of the boll, kapas, seed and lint weights per seed, lint length and fibre weight per unit length appear to be stable, the variation in the moisture percentage of the soil having no influence on them.

33. Studies on germination of sugarcane setts.

K. KRISHNAMURTI RAO, Coimbatore.

Sugarcane setts treated in hot water and setts obtained from canes 'topped' in the field give higher percentage of germinations. Pre-soaking of cane setts in different solutions does not give any definite result under the planting practice obtained at this station. The chemical changes that take place in some of the constituents of a sett when it germinates are noted. Some other factors that help germination are discussed.

34. A note on seed setting and seed germination in certain sugarcanes.

N. L. DUTT, M. K. KRISHNASWAMI, *and* K. S. SUBBA RAO, Coimbatore.

The seed germination of over forty varieties were studied for five to seven seasons. Varieties like P.O.J. 2725 gave uniformly high germinations, while *S. officinarum* forms such as Vellai, Chittan, etc. gave consistently low germination. The *S. spontaneum* forms topped the list. A judicious combination of *S. officinarum* and *S. spontaneum* blood in Co.'s 419 and 421 has resulted in these varieties giving seed of high germinating capacity. The attempt to improve germination by chemical means was not successful. While a certain amount of influence of the pollinating parent was evident, the high or low germination seems to depend more on the inherent capacity of the female parent. Seeds of sessile spikelets gave more germination than that of pedicelled ones in all the cases examined, including *S. spontaneum*. Some correlation seems to exist between size of the seed and thickness of the female parent.

35. Nature of the cause of gum formation in Pempheres attacked cotton plants.

S. KASINATHAN, Coimbatore.

The paper records the studies made regarding the causes of gum formation in cotton plants attacked by *Pempheres affinis*. Direct inoculation experiments indicate a pathogenic origin. It has been shown that organisms which can be isolated from the gum lesions produce a gummy

substance both *in vitro* and *in vivo*. The purified organism if introduced into the plant produces characteristic gum cavities and can be re-isolated from the material thus attacked. The cause of the gum formation is thus of a bacterial nature.

Crops—Insect Pests

36. Cotton jassids and hairiness of cotton plant.

M. Afzal Husain *and* K. B. Lal, Lyallpur.

It is commonly believed that the hairiness is a character that makes a cotton plant jassid resistant. It has been found that the nymphs and adults of *Empoasca devastans* Distant, can feed and develop on all types of cotton whether hairy or not. But on resistant varieties eggs are not laid. It has also been established that while resistant varieties are hairy, all hairy varieties are not resistant. Perhaps the real nature of resistance is different from hairiness.

37. The bird enemies of the cotton leaf roller (*Sylepta derogata* Fb.) at Khanewal (Multan, Punjab).

M. Afzal Husain *and* Hemraj Bhalla, Lyallpur.

The importance of birds in the control of insect pests is well known. A serious outbreak of *Sylepta derogata* (the cotton leaf roller) occurred in the American cotton fields near the forest area at Khanewal. The birds of the locality were shot, their stomach contents examined and their economic status determined.

38. Observations on the life-history of pink Bollworm (*Platyedra gossypiella* Saund) at Parbhani (Deccan).

H. D. Nangpal, N. T. Nadkerny, *and* T. E. Krishnaswamy, Parbhani (Deccan).

Observations on the life-history of pink Bollworm at Parbhani showed the presence of both the long cycle and short cycle courses. The long cycle moths started emerging after the break of the monsoon and continued doing so till January. The pre-oviposition period was six to ten days and five to seven days for the long and short cycle moths while the minimum and maximum period for which they continued laying eggs was six and forty-nine days and one and thirty-five days respectively. The maximum number of eggs 375 were laid by a long cycle and 266 by a short cycle moth. The duration of the different stages, egg, larva and pupa was studied in relation to the temperatures throughout the year. Larvæ went into hibernation any time from the middle of November to April. The maximum period lived by the long-cycle males and females was sixty-nine and fifty-six days while the short cyclers lived for thirty-nine and forty-six days. One life-cycle, egg to adult, took twenty-three to twenty-nine days from June to middle of October and twenty-five to forty-two days from 15th of October to end of February. There can be nine to ten generations of this pest in a year in this part of the country.

39. The *Tur*-pod fly *Agromyza obtusa* Mall.

Takshir Ahmad, New Delhi.

Although the *Tur*-pod Agromyza was recognized as a serious pest of *Cajanus indicus* over 25 years ago no attempt had been made to identify the species, to say nothing of its life-history and its bionomics. The pest

was noticed doing serious damage to Tur-pods on the Pusa estate during March 1936, when the bionomics of the fly and that of the parasites bred therefrom were investigated.

The eggs are laid inside young pods in which seed formation has already proceeded to some extent. The maximum number of eggs laid in the laboratory by one female in 24 hours was 28 and in her whole life-time 50. The eggs hatch in 2½ to 3 days at 27°C. This also represents the incubation period in nature during April. At 22°C. and 18°C. the eggs hatch in about 4 and 9 days respectively.

The young larvæ eat the surface of the seed, seldom boring right into it. The larval period is comparatively short, being 9-10 days at 27°C. The full grown larvæ pupate within the pod. The pupal period is 8-9 and 28 to 30 days at 27°C. and 18°C. respectively.

The adult flies are short-lived. If kept without food they survive 3 to 8 days depending on the temperature (27°–18°C.). When fed on honey solution the duration of their life is almost doubled and varies from 7 to 15 days.

It appears that there are a large number of broods in a year. *Tur* crop remains in the field from August to April. It has yet to be ascertained how the pest passes the period when the crop is not in the field.

Two larval parasites and one hyper-parasite have been reared out and are under study.

40. A new Cecidomyid pest (*Dasyneura lini* Barnes) of linseed in India.

H. S. Pruthi *and* H. L. Bhatia, New Delhi.

For the last few years this minute Cecidomyid fly has been observed doing damage to linseed flowers at Pusa. The extent of damage varied with the season and variety. The flies love sunshine and are most active during the bright part of the day. The eggs are laid some times on the outside but often inside the flower buds. The young larvæ on hatching work their way inside the bud. The larvæ live on stamens and other organs of the bud which consequently does not open. The larvæ become full grown in about 7 days and drop into the soil and pupate. The pupal period lasts 4 to 7 days, according to the room temperature. The most interesting and important point which requires elucidation is as to how and on what plants the pest passes the rest of the year. In this connection it is of interest to report that *Cajanus indicus* at Pusa was found being damaged by this or a closely allied species during February. The fly on *Cajanus* has been sent for naming to the specialist. If the species concerned in both cases is the same, then *C. indicus* is an important alternative host of the pest. The infestation in this host plant in the insectary compound varied from 18 to 53%. Thirty-three types of this crop grown in the plots of the Botanical section were also examined for this pest. Nine of them were found infested, the percentage of attack being 1–7%. The life-history of the fly infesting *Cajanus* was carefully investigated. The average duration of the egg, larval and pupal stages at 20°C. was 2, 6 and 7 days respectively. At 27°C. the duration was 1, 4 and 5 days.

In view of the proposed extension of linseed cultivation in India it is feared that this pest is likely to become of major importance in future.

41. Life-history and biology of the weevil borer (*L. truncatulus*) of Amaranthus.

Takshir Ahmad, New Delhi.

The Amaranthus weevil borer *Lixus truncatulus* is a pest of several cultivated and wild varieties of *Amarantus* spp. in the plains of India. The weevil can feed on a variety of plants but oviposits on a very

limited number of them. The eggs are laid inside the leaf petioles or in tender parts of the stem. A single female lays about two or three eggs per day only during the warm season. The grubs on hatching bore down through the secondary branches into the main stem. When full-grown they make wide chambers for pupation which cause characteristic swellings on the stem. In a case of severe infestation as many as 155 individuals in different stages of development were discovered from a single plant. The larval period seems to be very variable. On an average it varies from 1½ months in summer to several months during winter. The larvæ hatched during November and December pass the winter in the larval stage. The pupal period is about 9-10 days at 27°C. and 20–24 days at 20°C.

The life of adults is very long, sometimes as much as 148 days. There seem to be at least three broods from March to November, the individuals of last brood over winter in whatever stage they are, and resume development in spring.

A cecidomyiid maggot has been recorded for the first time feeding on the eggs of this borer. *Paruderus torymoides* F., a chalcid parasite has been bred from the eggs of the weevil. Another egg parasite and a larval parasite are awaiting determination.

42. Studies on *Stenobracon nicevillei*, a parasite of the sugarcane white moth borer Scirpophaga.

M. C. Cherian *and* P. Israel, Coimbatore.

The moth borers are serious pests of sugarcane all over India. One of these (*Scirpophaga* spp.), though not so serious as *Argyria sticticraspis*, does a fair amount of damage to the canes. In the course of the studies of its natural enemies in Coimbatore, five larval parasites have been noted and the paper gives detailed account of one of these, viz., *Stenobracon nicevillei*.

43. A new enemy of the Indian honey bee.

M. C. Cherian *and* V. Mahadevan, Coimbatore.

The Indian honey bee (*Apis indica*) has a number of natural enemies such as the wax moth (*Galleria mellonella*), the yellow banded wasp (*Vespa cincta*), the death's head moth (*Acherontia styyx*), etc. Recently, however, a new Sphecid wasp—*Palarus orientalis*—has been added to this list.

The wasp stings the worker bees and takes them to its underground nest and lays eggs on them. The grubs which hatch out grow in size by feeding on the bees and when full grown make cocoons and pupate inside these. In due course the adults emerge. By handnetting of the adults and destruction of their nests the pest can be reduced considerably in numbers.

44. Notes on the life-history and habits of *Dacus brevistylus* (Family Trypetidæ) a pest of *Coccinia indica* fruits.

M. C. Cherian *and* C. V. Sundaram, Coimbatore.

The paper gives detailed information on *Dacus brevistylus* a serious pest of *Coccinia* (*Cephalandra*) *indica* fruits.

Eggs are laid on the fruits by the adult females. The maggots hatch out in two or four days and feed on the pulp. These become full grown in four to five days and when the fruits drop to the ground the maggots go into the soil for pupation and emerge as adults in eight to nine days.

45. Studies on the incidence of the swarming caterpillar of paddy.

M. C. CHERIAN *and* K. P. ANANTANARAYANAN, Coimbatore.

Spodoptera mauritia Boisd., the swarming caterpillar of paddy, is long known to be one of the worst insect pests of young paddy in South India. In this paper are contained, some of the observations made on this insect during the past 2-3 years, as regards its seasonal appearance, incidence of the insect in relation to weather and crop and its habits in the initial stages of an outbreak. The studies strongly indicate the influence of weather conditions and microclimate of the crop in determining the severity of attack, and also the possibilities of adopting direct and indirect methods of control in the initial stages to prevent the insect's taking a serious pest condition.

46. The important insect problems affecting the cultivation of cocoanuts in Cochin State.

C. S. VENKATASUBBAN, Trichur.

Cocoanut is the most important crop of the State after paddy, and the pests affecting the crop have naturally claimed the foremost attention of the writer for the past thirteen years. An attempt is made in this paper to embody the main facts connected with insect pests infesting the palm in the State. Only the insects that have been doing damage, and those that have shown to possess definite potentialities of turning out to be pests, are included. In the former list are included *Oryctes rhinocerors* L; *Rhychophorus ferrugineus* F; *Nephantis serinopa* M; *Contheyla rotunda* H; *Parasa lepida* G; *Aspidiotus* Sp.; *Gangara thyrsis* M, and termites. *Cyclodes omma*, and the Elephant beetle—*Xylotrupes* Sp. are included in the latter.

47. *Oxya velox* F. as a pest of 'Kole paddy' in Cochin.

C. S. VENKATASUBBAN, Trichur.

A paper on 'Kole cultivation in Cochin with special reference to insect pests' was submitted by the writer to the 1933 Session of the Indian Science Congress. In this paper details are given of a severe outbreak of *Oxya velox* in the last 'Kole paddy' in April, 1936. This pest, although it occurs on the paddy crop chiefly from August to December, has not been noticed to increase to such dimensions and do very severe damage before. This is the first time that its attack has been noticed in Kole paddy in Cochin, and in the hot months of March and April. The pest caused severe damage by cutting the ripening ear heads in an area of nearly one square mile in extent. The outbreak serves to emphasize the necessity for Meteorological observations—especially in regard to micro-climate in any study of insect pests.

48. Marriage flight and colony founding of *Camponotus* (Tanæ-myrmex) *compressus* Latr.

P. N. KRISHNA IYER, Coimbatore.

Camponotus compressus has been under study by the author for some years now and some aspects of the study were presented by the author at the previous sessions of this Congress. The occurrence of the marriage flight of the species was noticed as early as April. The method

of inauguration of this phenomenon and the nature of the association of the sexes in the initial stages are described in detail. The favourable environmental conditions, particularly meteorological, which appear to contribute to awaken the sexes to seek union and the composition of a normal swarm are indicated. The phenomenon of terrestrial mating outside in the vicinity of the parental formicary has been observed to take place in an early afternoon. Some data which might throw light on the methods of colony founding as observed in nature and tested in captivity are also presented. The capacity and instinct of the fecundated queen of the species to bring up her earliest progeny unaided have been demonstrated by experiment. The paper concludes with a rough outline of the life-history of the first brood of workers together with an account of the peculiar habits of the queen mother in rearing the same.

Crops—Diseases

49. Leaf-curl of tobacco in North India.

B. P. PAL, New Delhi.

Leaf-curl is one of the most serious diseases affecting tobacco in North India and is probably identical with the so-called 'kropoek' and 'krul' diseases of this crop in Java and 'leaf-curl' in East and South Africa.

Investigations at Pusa have indicated that there are probably five types of leaf-curl with certain common characters, viz., dwarfing of plants, reduction in leaf-size, curling of the whole or portions of the lamina, presence of either vein-banding or thickening and greening of the veins in some or all of the leaves and a condensation of the inflorescence, the flowers of which are usually abnormal. While leaf-curl is transmissible in all cases by grafting, juice transmission experiments have so far given negative results. None of the types seem to be seed-borne.

The distinguishing features of each one of the types are given in detail but their differentiation has been made mainly on the basis of symptomology, as the physical and chemical properties of the different viruses have not been yet studied. There is reason to presume that four of the five types of leaf-curl are caused by distinct viruses and that the fifth type may be caused by a mixture of two or possibly more of them.

50. A preliminary study of chlorosis in sugarcane.

J. C. LUTHRA *and* I. S. CHIMA, Lyallpur.

A report was received in 1934 from Sonepat (Rohtak) that leaves of sugarcane plants in some fields had turned yellow. Some metabolic studies were carried out and the leaves of the chlorotic plants were found to be poorer in carbohydrate contents as compared with healthy leaves. The juice obtained from chlorotic plants was also found to have a lower percentage of sucrose. The rate of respiration of chlorotic leaves was 1·47 mgs. per gram dry-weight per hour against 2·0 mgs. for the healthy leaves. The chlorotic leaves also showed a higher content of iron and calcium. It seems that iron in the chlorotic plants is in a static condition and thus results in a disorder affecting formation of chlorophyll. Excess of calcium in the leaves also appears to be responsible for the deposit of iron in the leaves in unavailable form.

Of the various control measures tried, application of 0·01% iron salts to the soil and spraying with 8% solution of ferrous sulphate proved very useful in restoring green colour of the chlorotic plants.

51. A study of cultural variations in the gram blight fungus *Phyllosticta rabiei* (Pass) Trot.=*Ascochyta rabiei* (Pass) Lab.

J. C. LUTHRA *and* K. S. BEDI, Lyallpur.

Gram Blight:—*Phyllosticta rabiei*, the causal fungus, has been found to have several distinct strains. In nature they occur on gram plants both singly as well as intermixed. Some forms are so remarkably different from others that they could be taken as separate species. Different forms also originated in saltation from monosporous cultures. The saltants generally retained their distinctive characteristics in subsequent generations. In one case, a saltant exhibited the phenomenon of reversible mutation and gave rise to the parent form.

The various forms were cultured for a series of generations on a variety of media and at different temperatures. They always maintained their distinctive features.

In addition to cultural differences some of the forms also exhibited significant morphological characters.

As regards pathogenicity, the various forms are arranged in three groups :—

(i) intensely sporulating forms causing most virulent infection,
(ii) predominantly mycelial and moderately sporulating forms causing moderate infection, and
(iii) wholly mycelial and sterile forms causing no infection.

52. *Cytospora sacchari* Butl. on sugarcane.

J. C. LUTHRA, ABDUR SATTAR, *and* SARDUL SINGH, Lyallpur.

A rind disease of sugarcane caused by *Cytospora sacchari* was first noticed in the Punjab, at the Sugarcane Research Station, Risalewala, Lyallpur, in March, 1935, on several Coimbatore varieties. The disease was also discovered on Co. 244 at Sonepat. In January, 1936, the disease was reported from Muzaffargarh on Co. 223. In March, 1936, the disease reappeared at the Sugarcane Research Station, Risalewala, on the following varieties :—Cos : 223, 244, 312, 313, 370, 373, 374, and several others.

The most prominent symptom of the disease is that black hard bodies (pycnidia) develop on the rind. All internodes or only some of them may bear spore-bodies on the rind surface. Leaf sheaths have also been found to be infected. Observations show that the disease may be present inside the standing canes and pycnidia may not appear on the rind. Pycnidia are mostly formed when the canes get dried up or when they are buried underground. In the case of canes of Co. 313 buried during January, 1936, to save the seed from frost, over 3 per cent. were found to bear pycnidia in profusion.

Some of the affected setts may not have any symptoms at the time of planting but the canes grown from them have been found to wilt.

53. The rotation of tobacco for the prevention of wilt disease in pigeon-peas (*Cajanus indicus* Spreng).

R. D. BOSE, Pusa.

Experimental data are presented to show that the tobacco crop in rotation with pigeon-peas helps to control the incidence of wilt (*Fusarium vasinfectum* Atk.) in the latter crop to a large extent. It is believed that the sterilizing effects of the nicotine content of the buried roots and stumps of tobacco stems are responsible for checking the growth and activity of the fungus and thus retarding the attack of wilt on the host plant.

It is advocated that wherever possible tobacco should be grown, at least once in three years in fields where pigeon-peas are usually raised and where wilt takes a heavy toll from the latter crop. In low-lying lands where the cultivation of tobacco would be unprofitable it may be enough to obtain stumps of tobacco stems from elsewhere and to bury these in the soil a couple of months before sowing pigeon-peas.

54. Effect of bunt (*Tilletia indica*) on wheat.

M. MITRA, New Delhi.

In order to find out the effect of *T. indica* Mitra on the ears of wheat plants, fifty bunted ears of Pusa 165 wheat were collected at random from Karnal during 1934-35. The length of ears and the number of spikelets in each ear were noted and compared with fifty normal ears which were also collected at random. During 1935-36 a similar comparison was made of 309 ears of P. 80–5, 433 of P. 165, 218 of Punjab 8A and 132 of Cawnpore 13 and previous years' conclusions were confirmed. It was found that like the other two species of *Tilletia* occurring on wheat, this species also causes reduction in the length of the ear. Moreover the number of spikelets also is reduced.

55. Soil infection as a factor in the transmission of wheat bunt.

M. MITRA, New Delhi.

In order to determine how far soil infection by *Tilletia indica* Mitra is responsible for the production of bunt in wheat in addition to that by seed-borne spores, experiments were carried out at Karnal during 1935-36. The data obtained shows clearly that when healthy seed is sown in infected soil, bunted ears are formed to a certain extent. Further it is noticed that treatment of healthy seed with certain fungicides such as Hortisan A, sulphur and Agrasan G reduces the incidence of the disease if seed is sown in infected soil. As soil infection takes place and one year's rotation is not enough a longer crop rotation is suggested.

56. An anthracnose disease of Sann hemp.

M. MITRA, New Delhi.

A disease of sann hemp causing considerable amount of damage was noticed for the first time at Pusa during August, 1935. The causal organism was found to be *Colletotrichum curvatum* Briant and Martyn, previously recorded from the West Indies. The infection experiments carried out proved its pathogenicity. The disease is very virulent during the seedling stage of the host plant and especially if seed is sown late when the weather is moist and cloudy. Early sown crop generally escapes the disease and with the age the plant becomes less susceptible to the disease. Seed treatment checks the infection to some extent and spraying is found to be helpful only if the weather is dry. During 1936 the disease was again noticed in plots where late sowing was done.

Crops—Field and plot technique and statistics

57. Border effects in manurial experiments on cotton.

B. M. DABRAL *and* S. S. CHINEY, Sakrand (Sind).

With a view to study the effect of inclusion or rejection of border yields from the total yield of a plot, the yields from border rows and

central portions of plots under manurial experiments on cotton were separately picked and weighed. The data were subjected to statistical analysis and it was found that, with the inclusion of border yields : (i) the percentage increase in the total yield was highest in control plots while in the treated plots percentage increases regularly diminished with increasing quantities of manure, and (ii) the standard error of the experiment was also reduced and, as a consequence, improved significance. Therefore, under the experimental conditions particularly the uniform distribution of manure, the effect of inclusion of border yields lessens with applications of manure and as such it is considered possible that in manurial experiments rejection of border yields is of little advantage.

58. Uniformity trial with sugarcane in Assam.

L. PHUKAN *and* S. S. BOSE, Calcutta.

A uniformity trial experiment was conducted in Jorhat Farm (Assam) with sugarcane (Co. 290) with a view to determine the optimum shape and size of plot for future field tests. The smaller plot size was $13' \times 3'$ and in all 16 combinations of 4 length units 13′, 26′, 65′ and 130′ and 4 width units 3′, 6′, 12′ and 16′ were analyzed. It has been found that although the smallest plot ($13' \times 3'$) showed the highest precision, the error of plot sizes ($26' \times 3'$ or $13' \times 6'$) was only 3 p.c. higher. Bigger plots led to considerable enhancement of error and should be avoided, as far as possible.

59. A note on sampling in sugarcane experimental work.

M. VAIDYANATHAN *and* T. KRISHNAMURTI, New Delhi.

Various methods of sugarcane sampling now adopted in sugarcane stations in India, and discussion of their merits—Principles of sampling technique, and the various statistical constants necessary for judging the efficiency—Reference to previous work in other countries—Points to be considered in sugarcane sampling. Suggestions for systematic work on sampling.

60. A new method for the estimation of variance when plot yields are missing from field experimental data.

P. V. KRISHNA IYER, New Delhi.

The method consists in estimating the actual value of the residual errors of the various plots by using the assumption made in the statistical analysis of data which satisfy the conditions of orthogonality. Let there be n treatments, T1, T2, T3, ... Tn, each being replicated s times. The errors due to unknown causes for the various plots are assumed to be $a1$, $a2$, $a5 \ldots an$, $b1$, $b2$, $\ldots bn \ldots s1$, $s2$, $s3 \ldots sn$. The values of the residual error corresponding to the plots missing, say, l, are assumed to be zero. In such a case we have ns-p unknowns and it has been shown how ns-p equations involving the unknowns and the recorded yields can be formed. These equations will enable us to determine the ns-p unknowns. Knowing these, the sum of squares due to residual error is equal to the sums of squares of the unknowns determined, the degrees of freedom being (ns-p-n-$s+1$). Thus we are in a position to estimate the variance without actually determining the yield of the missing plots, and knowing the standard error it is easy to compare the differences between the means, whatever be the number of replications for each treatment. The method is capable of being utilized for both the two layouts that are generally used by agricultural workers.

61. A note on the use of 'efficiency' criterion for agricultural experiments.

P. V. Krishna Iyer, New Delhi.

The note deals with the methods and corrections to be employed in determining the comparative 'efficiency' of mean, standard deviation and coefficient of variation with special reference to the estimation of the best size of plots for experimental purposes on the basis of uniformity trials from a fixed area.

The expressions for the 'efficiency' of mean and standard deviation are the same and when corrected for both plot-size and number of replications it is given by S^2_{1a}/S^2_{ra}, where S^2_{1a} and S^2_{ra} are the variances for sizes *a* acres and *ra* acres respectively. The best method appears to be the one based on the standard errors of the coefficient of variation. The expression for the comparative 'efficiency' of the coefficient of variation for two plot-sizes has also been given.

62. On the application of L_2 criterion to field experiments in agriculture.

S. Subramania Iyer, New Delhi.

The application of the method of analysis of variance to field experiments when a single variable, say plot yield, is studied is now a matter of common knowledge amongst agricultural workers in India. When a number of variables are to be studied the need is often felt for a preliminary comprehensive analysis taking into account the effect of the varieties or treatments on all the variables. L_2-criterion developed by Statisticians in the study of multivariate problems supplies us with such a criterion for well planned field experiments. A sugarcane varietal trial (7 varieties in 6 randomized blocks) is analyzed in this paper and L_2-test is employed to show the significant effect of the varieties on three variates, viz., plot yield, sucrose percentage and glucose percentage; ordinary analysis of variance on the factors considered separately also shows high varietal significance.

Agricultural Chemistry

63. Possibilities of establishing the otto of rose industry in India.

N. G. Chatterji, Cawnpore.

A general paper based on personal study of the industry in Bulgaria. A careful analysis of all the various important factors shows that there is every possibility of firmly establishing this industry in India.

SECTION OF MEDICAL AND VETERINARY RESEARCH

President :—Col. A. Olver, C.B., C.M.G., F.R.C.V.S., F.N.I.

Presidential Address

THE RELATION OF ANIMAL NUTRITION TO PUBLIC HEALTH IN INDIA

Ladies and Gentlemen,

Before proceeding with my address, I must express my very sincere thanks for the honour of having been invited to preside over the Medical and Veterinary section this year: an honour which, I can assure you, I accepted with considerable trepidation. For apart from any difficulty a veterinarian must experience in dealing adequately with purely medical questions, I have for a long time past been engaged almost exclusively with administrative matters and I have found it difficult to select a suitable subject for my presidential address. In the end I have decided to discuss what, besides being of wide scientific interest, is at the moment a highly topical subject, and one of very great practical importance, particularly to the people of India, viz., the many and varied problems which are involved in providing a more adequate diet—for farm livestock as well as for the people—at a cost which is not prohibitive for the comparatively poor.

Probably the greatest and most difficult of all the problems which Governments have to face in India to-day is the problem of providing, at a cost within the reach of the masses, an adequate and satisfactory supply of the protective foods of animal origin, especially milk. In spite of every effort to find effective vegetable substitutes these foods have, in recent years, been shown to be irreplaceable in human diet and owing to the rapid increase in population which is taking place, this problem is becoming daily more difficult. It is clear in fact that the best possible use will have to be made of all the food resources which are or could economically be produced from the available land and it is here that Animal Nutrition has a great role to play in the maintenance of public health. Only by systematic and properly controlled investigation of the feeding values of locally grown foodstuffs, in relation to the requirements of the livestock of the country, is it possible to make the best use of the great variety of cattle foods which can satisfactorily be grown under the varying conditions of soil and climate which exist

in this sub-continent. Besides being of the greatest importance to the health and development of the people systematic investigation, throughout India, of the food values of such cattle foods as are produced is moreover a matter of huge economic significance and I propose to discuss very briefly a few points of mutual interest to human and animal dieteticians and to suggest ways in which it seems possible, by proper attention to the nutritional requirements of farm livestock, to make available at reduced cost larger and better supplies of these protective foods.

Before considering the problem of economic production it is however necessary to have some authoritative basis on which to found our conceptions of what is needed for the proper nutrition of the human race and, until further research has been carried out, in India, we cannot do better than adopt the standards which have recently been published by the Health Organisation of the League of Nations, in the report of their meeting held in London in November 1935.

From this report and the attached tables it may be seen that great emphasis is laid throughout on the essential importance, to the proper development and maintenance of health, of foodstuffs of animal origin and particularly of milk and eggs. It may be that strict vegetarians will still contend that the necessity for animal foods in human diet is not fully proven but it is clearly impossible for any official body, concerned with the proper nutrition of a people, to ignore such an authoritative and definite pronouncement as this, by a body of scientists who during the past 10 years have been engaged, under the auspices of the League of Nations, in determining firstly what an optimum diet for the human race should consist of and secondly how far it is feasible, in existing circumstances, to provide an ideal or better diet for the generality of the people.

Moreover their views have of recent years received more than ample confirmation from the controlled observations, which have been and are being carried out in so many countries, as to the effect of an addition of some milk to the ordinary diet of school children and others, whose diet would otherwise consist mainly of the cheaper vegetable foods.

The Commission also stressed the importance of proper diet in relation to the prevention of disease, an aspect of nutrition to which McCarrison working at Coonoor was among the first to draw particular attention.

Indeed McCarrison appears to have been the first to clearly demonstrate the great possibilities of controlling infection by the provision of an ideal diet, associated with strict attention to Hygiene.

Previously, during the later years of the past century, Voit had already shown that a proper proportion of minerals in the diet is essential to proper utilization of foodstuffs, and

Theiler and his co-workers in South Africa had demonstrated the causative role of mineral deficiencies in relation to a group of livestock diseases, e.g. Lamziekte and Osteo-dystrophia, which previously had not been properly understood. By co-ordinated veterinary and bio-chemical research he showed that nutritive defects, consisting mainly of inadequacy of minerals and vitamins, were the primary cause of the reduced resistance and increased exposure to infection from which, in their attempt to rectify these deficiencies, South African livestock, over wide areas of arid country, contracted the infection which ultimately caused sickness or death.

The great importance of Theiler's work however lay in the fact that he was the first to demonstrate clearly the causative role of faulty nutrition in regard to a large group of diseases from which farm livestock, in various parts of the world, are liable to suffer and which at one time made the rearing of livestock difficult and even impossible over large areas, in many countries.

Since these pioneer observations were made the essential importance of mineral matter for the proper growth, development and reproduction of experimental animals has repeatedly been demonstrated and Orr and others, quick to realize the importance of Theiler's work, have extended widely his observations as to the causative role of mineral and vitamin deficiencies, in a wide range of stock diseases, in various parts of the world.

One need only mention the group of diseases on which Theiler's initial observations were made in South Africa, and the so-called Bush-sickness of New Zealand and other countries, due to iron deficiency, to illustrate the great economic importance of an adequate supply of minerals in animal diet, and though the field has scarcely been scratched recent systematic investigation of stock diseases in this country, carried out by specially employed Veterinary Investigation staff and others, has shown that evidence is by no means wanting of severe marasmus and mortality among livestock in India, traceable to deficiencies of essential mineral matter in the foodstuffs available.

Modern research on the vitamins has led also to a far more exact appreciation of the principles on which the feeding of livestock must be based and the importance of the accessory food factors in animal nutrition is now no longer disputed. Owing largely to their elusive nature and the comparatively minute quantities required they were long regarded as something in the nature of a medical fad but there is now ample evidence that these substances do play a most important role in the nutrition of farm livestock, as well as in that of human-beings. For example in India it has recently been shown that a vitamin A deficiency is the main causative factor in the production of a specific form of blindness with which, until measures were

taken to provide an adequate supply of fresh green stuff to the herd concerned, approximately 40% of all the calves produced were affected, most of them being totally blind at birth and many unable to carry on an independent existence. Thorough investigation of the conditions under which this herd was maintained combined with controlled experimentation, carried out subsequently at the Muktesar Institute, has since shown that the condition of these calves was due to a lack of vitamin A in the diet of the herd; which at that time had little land at its disposal for the production of green fodder. It was in fact shown that the condition could be produced by feeding pregnant cows on an autoclaved diet which, in other respects, was similar in composition to that on which large numbers of cattle are regularly maintained at the Institute in perfect health.

In the course of these experiments it was moreover shown that it is not possible to maintain cattle for any length of time on autoclaved food. For very shortly after being placed on such a diet the cows under experiment lost condition so rapidly and became so obviously ill that it was necessary to add a proportion of un-autoclaved food to the ration to obviate vitiation of whole experiment owing to demise of the experimental animals.

The essential importance of an adequate supply of vitamin A to cattle was thus clearly demonstrated and it is of interest that similar cases of natal blindness in calves have since been detected in other parts of India, particularly in big cities, where the diet consists mainly of dry fodder and concentrates.

It is also of considerable interest to human dieteticians that in the course of these investigations instances occurred of calves, born from mothers which had previously received an ample supply of green fodder, which developed this form of blindness within a short period of arrival at the station concerned, where as mentioned above the supply of green stuff was very deficient. These observations seem to indicate quite clearly that the milk from cows fed almost exclusively on the dry food materials on which cows are usually fed in city dairies in India and during the dry season in many parts of India is very lacking in vitamin A. It is rational therefore to assume that the milk of .cows maintained in city dairies where adequate supplies of green fodder are costly and difficult to obtain cannot usually be considered a satisfactory food, particularly for children. This is a point which I am sure deserves much greater attention than it has hitherto received from the general public.

Aykroyd and others have on the other hand recently demonstrated that striking improvement in the health and development of school children in India can rapidly be effected by the addition of small quantities of cows milk to their diet and it is a matter of very considerable importance to human dieteticians in India that in the course of these observations it has been shown that skimmed or separated milk—or reconstituted

milk made with skimmed milk-powder—are very valuable foods when taken along with adequate amounts of great leaf vegetables or fruit and adequate exposure to sunlight. It seems in fact that while the supply of vitamin A and of carbohydrates may be adequate in the ordinary diets of India, the content of protein of high biological value and of the essential minerals and other accessory food factors, which are contained in skimmed and separated milk, and in milk-powder, must be definitely lacking in those diets. Great improvement in health and physique could therefore be effected, at comparatively small cost, if the consumption could be increased of skimmed or separated milk or of milk-powder—in which all the proteins and mineral salts of whole milk are preserved, almost in tact.

In considering the proper nutrition of a people it is moreover necessary to go right down to fundamentals such as the composition of the soil on which the foodstuffs consumed by livestock are produced and to such matters as the effect of different systems of cultivation and grazing on the quality of the cattle foods produced, and this brings me to another aspect of nutrition to which I wish to refer, viz., the quality of the proteins available in foodstuffs of animal origin. In the past, in estimating the feeding values of foodstuffs, attention was paid mostly to the quantity of carbohydrate, protein and salts, present in the various constituents of the diet, but in more recent years the essential importance of animal proteins of high biological value has become more and more recognized. The quality of the amino acids which enter into the composition of a diet is in fact a matter of great importance to the dieteticians and this is a factor in relation to which the nutrition of farm livestock and indeed of the crops on which they are fed must play an important part in human nutrition.

For example, it is well-known by expert stock-breeders and feeders that the quality of their stock and the price they fetch in the market depends very largely on the quality of the foodstuffs upon which they have been reared and maintained, and for that reason good graziers and stock-breeders have always paid particular attention to the proper manuring and management of their grass-land and to quality in the food-stuffs fed to their stock.

But until comparatively recently it was generally assumed that the difference between the results obtained from good and poor pastures lay mainly in the higher protein and starch content of the former.

Orr and his co-workers have however shown that the most important difference between grass grown on well-managed land or under artificial cultivation and that produced on poor pastures lies in the comparatively high mineral content of the former. They have further shown that if the mineral content falls below a certain point the material becomes unpalatable

to stock and is refused, while the absorption of such minerals as are present in overripe and innutritious fodders is defective.

To a country such as India where every year there is a period when natural growth of succulent fodder is almost at a standstill and where the foodstuffs available for stock are mostly dry, overripe, crop residues which have long been exposed to sun and rain, these observations are of the utmost practical importance, to human as well as animal dieteticians since the provision for stock of a diet of good quality presents difficulties which are not at all met with in countries where rainfall is more evenly distributed and sunlight is not so intense.

It is thus essential for the proper feeding of the people in such a country that facilities should be provided for systematic research on the composition and proper conservation and utilization, by indigenous types of livestock, of such fodder and other food material as can be made available at reasonable cost.

In this connection it is necessary always to remember that we have evidence to show that the capacity of Indian cattle, of pure Indian origin, to utilize comparatively dry and innutritious foodstuffs, is high compared with that of cattle of European origin and higher in some breeds than in others, while it seems that the hump or fat tail which is so commonly met with in desert animals and in Indian livestock may be of greater significance in nutrition than has commonly been supposed.

But though it is a truism that well-fed meat and milk of good quality are of higher biological value than similar material of lower quality it seems to me little understood in India that an adequate supply of such high quality foods can only be produced by the provision of a better supply of nutritious and easily digestible foodstuffs. Fodder crops of good quality can in fact only be grown under a system of cultivation or management of grassland which is calculated to furnish an ample supply of plant food.

A system of mixed farming, combined with proper management of grasslands and suitable conservation of cattle foods of good quality, is thus a matter of great importance to human dieteticians as well as to the farming community. For the coarse rank grass which is grown in the wetter parts of India is so deficient in nutritive value and becomes so indigestible that it is not possible to produce high grade stock or animal products of good quality without making provision for supplementing this diet by an adequate supply of specially grown fodder crops or concentrates. Cattle reared exclusively on such grass are indeed commonly so poor that they are of little use as work or milch animals and rightly fetch such low prices for slaughter that their production is an unremunerative drain on the fodder resources of the country.

We are faced here with the apparent paradox that in India the best developed cattle are produced in areas where the natural

growth of grass is comparatively scarce. But in fact the position is not so paradoxical as it may seem, since in dry areas stock-owners are forced to provide supplementary foodstuffs of comparatively high biological value for their stock. Further, in order to keep them alive during periods of drought and to meet the cost of providing supplementary foodstuffs they are forced to maintain only such numbers of comparatively good cattle as can produce sufficient return, from milk, or form the production of valuable work animals, as will justify the outlay on fodder production, while such grass as is produced is usually of comparatively high feeding value.

How to make the production of suitable fodder crops economically possible in a system of agriculture which must perforce be governed largely by the very limited capital resources of the Indian cultivators, is however one of the most difficult of the problems with which the better nourishment of the people of India is unfortunately beset.

In existing circumstances it is obviously difficult for poor cultivators to modify the present unsound system of agriculture, in which attention is so often almost exclusively paid to the production of cereal grains or other cash crops, but it seems clear that any improvement in the feeding of the people must depend very largely on the success which is achieved in modifying this system.

Moreover it is fully recognized that, particularly in hot climates subject to seasonal droughts and a tropical sun, nothing can take the place of humus in maintaining the fertility of the soil and it seems that, in order to maintain fertility, the rearing and maintenance of better cattle under semi-stall feeding conditions by the introduction of more fodder crops into the rotation, must be an important factor in the solution of the cognate problems of human and animal nutrition in India. Though it is obviously difficult for a poor cultivator to find money for fodder crops, from which he is usually unable to obtain a direct cash return, it would in my view be wrong to adopt a defeatist attitude in this matter. It has in fact been demonstrated in various parts of India, that where a steady market for animal products has been provided, e.g. for milk or ghee, the cultivator has found ways and means of obtaining, and maintaining satisfactorily, the stock of better class which are needed to enable him to get a satisfactory return from his outlay.

The provision of up-to-date facilities for the rapid transportation, under satisfactory conditions, of perishable animal products, from the mofussil to big cities, and for better control and proper development of the marketing of such products, are thus matters in regard to which money invested by Governments should receive an ample return in the improved health and prosperity of the people.

Indeed the scientists of India could turn their attention to no greater or more stimulating task than that of providing an increased supply of cattle foods of good quality all the year round and of finding ways and means of developing in Indian villages a system of balanced agriculture by which the people could be better fed and the wealth of the country increased. In this task it is clear that systematic Animal Husbandry will have to play a very important part, since at present, owing to lack of precise knowledge of the food values of the foodstuffs usually produced in India, and of their utilization by Indian livestock, huge quantities of valuable food material are undoubtedly to a large extent wasted.

Mr. Bruce, the Premier of Australia, stated sometime ago that the time had come when Agriculture should be married to Public Health and I would particularize that, in India, Agricultural Science and organized Animal Husbandry should be intensively applied, in collaboration, to this problem of the economical production of the protective food-stuffs of animal origin, an increased supply of which is particularly necessary for the proper health and development of the people of this country.

I suggest that the solution must to a very large extent lie in educating the public as to the essential importance to health of an adequate and sound supply of milk and other food-stuffs of animal origin and in providing better facilities for their production, preservation, transportation and marketing, so that village cultivators and stock-owners may be able to produce more fodder crops, to supplement the grazing available, more and better farmyard manure or compost, and better stock; thereby increasing their income and the nutrition of the family while maintaining the fertility of their holdings and making a substantial contribution to the maintenance of public health.

SECTION OF MEDICAL AND VETERINARY RESEARCH

Abstracts

1. The triangular problem of nutrition in India.

F. WARE *and* K. C. SEN, Muktesar.

In this article an attempt is made to describe the subject of nutrition in India from the veterinary standpoint. A brief survey is made of the consuming populations, both human and animal, and the amount of cultivable land and grazing area available. The point is stressed that in India the subject of nutrition differs very greatly from the same subject in most other countries of the world in the fact that, while it is necessary to provide sufficient fodder for an enormous population of transport animals, there is no possibility of directly converting these animals into food for the human population at any stage of their existence. The result of this is that, to a large extent, the human and animal populations of India will always be in competition for the fodder which can be grown on the available land.

Some details are given of the work which has already been done on animal nutrition in this country and suggestions are made in regard to the lines on which this work should be continued in future, with a view to meet the difficulties which are likely to be encountered in any attempt to improve the general standard of nutrition in India.

2. Biological value of proteins of *aus* and *aman* rice and of rice polishings by the balance sheet method.

K. P. BASU *and* M. N. BASAK, Dacca.

(1) The biological value of proteins of polished rice both for Aus (Dharial) and Aman (Bhasamanik) varieties (pure line strains) is 80 and the digestibility is also the same (96%) for the two varieties. The protein values of Aus and Aman rice are 4·73 and 5·53 respectively.

(2) The biological value of proteins of rice polishings (both from aus and aman) is 68, and the digestibility of the proteins of polishings from aman is 77·8, while the digestibility of the proteins of aus polishings is 62·6. The polishing from aus and aman have got protein values 4·77 and 7·06 respectively.

(3) Parboiling has no effect on the digestibility as well as on the biological value of proteins of polished rice.

(4) There is no supplementary relation between proteins of rice and pulses.

(5) For rats weighing from 100 to 300 gms., the body-weight of rats does not appear to exert any appreciable influence on the biological value of proteins.

3. Biological value of proteins of *aus* and *aman* rice and rice polishings measured by the growth of young rats.

K. P. Basu *and* M. N. Basak, Dacca.

(1) At 5% level of proteins in diet, aus rice as well as rice polishings from aus and aman rice fail to cause any growth in young rats—maintenance is usually observed, although there is, often, a decline in weight.

(2) Aman rice at 5% level of protein causes a very good growth, the growth per gram of protein being 2.

(3) For the growth of young rats, aman rice proteins are much superior to wheat proteins, which cause a growth of 1·42 per gram of protein at 5% level.

(4) There is a supplementary relation, so far as growth is concerned, both between rice (aman) and green gram, and between rice (aman) and lentil proteins—that between rice (aman) and green gram being specially remarkable.

4. Nutritive value of proteins of soy bean, field pea and *Lathyrus sativus* measured by the balance sheet method.

K. P. Basu *and* R. Mukherjee, Dacca.

(1) The biological values of proteins of soy beans at 5, 10, and 15% levels of feeding are 64, 58 and 54 respectively, while those of the cooked product at the same levels of feeding are 52, 50 and 47 respectively.

(2) The biological values of field pea and *Lathyrus sativus* at 10 and 15% levels are 48, 41 and 50, 44 respectively.

(3) The biological value decreases, in all cases, with increase in the concentration of the protein in the diet.

(4) The protein values of soy bean, cooked soy bean, field pea and *Lathyrus sativus* are 20·2, 18·5, 11·7 and 14·4 respectively, at a 10% level of intake.

(5) There appears to be a slight supplementary relation between the proteins of wheat with those of soy bean and field pea.

(6) There is no supplementary relation between the proteins of field pea and *Lathyrus sativus*.

(7) Soy bean is superior to both field pea and *Lathyrus sativus* in biological value, but the digestibility is somewhat less.

(8) The proteins of field pea and *Lathyrus sativus* are of about equal biological value.

5. Nutritive value of proteins of soy bean, field pea and *Lathyrus sativus* by the growth of young rats.

K. P. Basu *and* R. Mukherjee, Dacca.

(1) The biological values of the proteins of soy bean, field pea and *Lathyrus sativus* have been determined by the numerical method of Osborne, Mendel and Ferry. Growths per gramme of protein ingested in these cases at 15% concentration are 1·4, 0·9 and 0·6 respectively.

(2) With 10% of protein in the diet the values in the case of soy bean and field pea are 1·6 and 1·0 respectively, while in the case of *Lathyrus sativus* a very slight growth is obtained.

(3) For the growth of young rats, soy bean proteins are superior to those of field pea and *Lathyrus sativus*, while of the last-mentioned pulses the former is better.

(4) Rats on *Lathyrus sativus* showed loss of fur, which could be remedied by the addition of a daily dose of 10 mg. tryptophane to the diet.

(5) There is no supplementary relation between the proteins of the two pulses.

(6) The maintenance requirement for rats weighing from 40 grammes to 80 grammes appear to be the least in the case of soy bean and greatest in the case of *Lathyrus sativus* proteins.

6. Serological investigations and typing of Meningococci.

P. T. Patel, Bombay.

The autnor ι as worked on a large number of cases of Meningococcal· Meningitis in the past (1921–24) and also during the recent epidemic of Meningococcal Meningitis in Bombay (1935-36).

Investigations were carried on with a view to finding out the type of Meningococcus prevalent in Bombay.

Type II was the most prevalent organism in Bombay during the years 1921–24.

Type I was found to be mostly predominating during the recent epidemic (1935-36).

7. Problems, studies and fallacies in the normal hæmatology of women living in Bengal.

H. N. Chatterjee *and* C. C. Basu, Calcutta.

Various constituents of the blood were examined in 134 'normal' women living in Bengal. These include the total red cells, hæmoglobin, corpuscular volume, sedimentation rate, reticulocytes, total and differential count of leucocytes including Schilling count, the diameter of red cells by Camera Lucida (Price-Jones Curve), by the volumetric method and by the Halometer, mean corpuscular thickness, mean corpuscular volume, mean corpuscular hæmoglobin and the different indices.

The mean average as well as the minimum and maximum figures are given ; various abnormalities have been obtained, and endeavour has been made to explain these as well as to suggest new work in this direction.

8. A preliminary investigation into the incidence of Entero-toxæmia among sheep in the Madras Presidency.

G. R. Viswanathan, Madras.

First record in this Presidency : A fatal disease, with nearly cent. per cent. mortality is described, characterized by sudden onset and death with bleating after collapse. Diarrhœa occurs in rare instances. Well nourished, mostly adult ewes are affected especially during grass sprouting season after rains indicating seasonal incidence.

The post-mortem appearances are congestion of the abomasum and the intestines with injection of the mesenteric vessels and the presence of serous fluid in the body cavities. Rarely small ulcers are noticed in the jejunum.

Bacterial examination : B. welchii has been isolated from the lesions on alkaline liver broth and Robertson's media. Toxin anti-toxin experiments on experimental animals were positive for B. welchii and the disease was diagnosed provisionally as Entero-toxæmia due to an organism of the B. Welchii group. Culturally, morphologically and biologically the organism appears to be B. welchii. Feeding experiments remain to be done.

The disease is clinically suggestive of Anthrax but experimentation of smears and biological tests do not bear this out. In one outbreak the disease has been controlled by vaccination with a vaccine locally prepared. Further investigation and experiments will have to be undertaken.

(i) The organism isolated from cases of the disease is pathogenic to rabbits, guinea-pigs and white mice.

(ii) It has an exo-toxin, pathogenic to experimental animals.
(iii) The toxin is neutralized by B. welchii anti-serum but does not become neutralized by B. paludis serum.

9. Investigation into the blood pictures, specially of leucocytes, in pulmonary tuberculosis.

B. Jayaram, Mysore.

1. The blood picture in normal individuals.

2. Variation in the blood picture in pathological conditions. There is a change not only in the absolute count of different kinds of cells but also in the relative proportions of the cells. Secondly there is a change in the type of cells, more immature cells being flooded into circulation.

3. Various authors have worked on this subject and their observations.

4. Work done in the Sanatorium since 1929.

Blood counts in normal individuals as control.

Blood counts—absolute and differential counts of leucocytes taken at different periods during patients' stay. Leucocytes classed as neutrophils, eosinophils, monocytes, and lymphocytes. Caseating and acutely febrile cases show a high percentage of neutrophils and small percentage of lymphocytes. Caseo-fibrotic and fibrotic cases—the ratio is upset but not to the same degree as the above. Early cases do not show much variation.

5. Clinical value with reference to Turban Gerhardt Inamn's classification and the bearing it has on the probability or otherwise of cure.

The higher the neutrophils count the worse the prognosis.

The higher the lymphocytic count the better the prognosis.

Other cells do not show much variation. Patients progressing well show a ratio approaching the normal one.

A case with a small anatomical lesion but with very high temperature and systemic disturbances shows a higher neutrophil and lymphocytic ratio and the prognosis is bad, whilst there may be a case with extensive lesions in the lungs but with very little systemic symptoms where the neutrophil and lymphocytic ratio will be low and the prognosis is good.

6. Statistician's note.

7. Conclusion—frequent examination of blood will give us an insight into the degree of systemic disturbances in the patient, and will help us in the line of treatment to be adopted.

10. A study of some of the anæmias of India based on the different indices of blood.

H. N. Chatterjee, S. M. Ghosh, *and* Brajendra Mahalanobis, Calcutta.

A study of some of the anæmias found in this country is made based on the different indices of the blood and data are given showing how they give valuable information about the pathology of blood. The associated changes in blood are also considered.

11. Two unrecognized forms of lymphangitis in horses.

S. C. A. Datta, Muktesar.

The occurrence of several forms of equine lymphangitis, such as epizootic lymphangitis, farcy, ulcerative lymphangitis, 'monday morning sickness,' is known, and as a result of our recent experience two other forms have now to be added to this list.

During the last two years, multiple or sporadic cases of these were encountered among cavalry horses, in different stations in Northern and Central India. The clinical picture presented was indistinguishable from that due to *Cryptococcus farciminosus*. The movement of animals had to be restricted and considerable anxiety was caused.

Staphylococcal. This was the more frequent of the two forms, and it developed as an acute disease, responding readily to ordinary treatment. Staphylococci were invariably present in large numbers in smears from the lesions, *Staph. pyogenes aureus* was recovered in pure culture, and the disease was experimentally reproduced in three horses. The recovered experimental horses were found to be still susceptible to further infections, and no immunity resulted from attacks.

Streptococcal lymphangitis. This form was persistent and showed no tendency to spontaneous healing. Numerous streptococci in long chains to the exclusion of other organisms, or sometimes in conjunction with them, were detected in the pus smears received, and *Str. equi* was isolated in culture from one case. Symptoms of strangles appeared later and confirmed the opinion that some of these were cases of irregular strangles.

12. Urinary calculus in the rabbit.

M. Y. MANGRULKAR, Muktesar.

The occurrence of an unusually large and rounded calculus, in the urinary bladder of a rabbit is reported. The finding is of interest, as 'Stones' in smaller laboratory animals are not commonly met with and if small, may be overlooked at post-mortem examinations. In the present case, the attention of the author was drawn to the condition by the distension of the bladder with about 20 c.c. of blood-tinged urine. The calculus was 2 cm. in diameter, and weighed 7 grammes. It had a distinctly laminated interior and consisted mainly of calcium carbonate.

13. A case of neoplastic nodules on the peritoneum.

M. Y. MANGRULKAR, Muktesar.

The article contains a histopathological study of a very rare tumour from a horse, appearing as nodular growths on the serous surface of the abdominal viscera. Portions of the liver, spleen, diaphragm and omentum revealed the nodules to be composed of large epithelioid cells, arranged in masses separated by a fibrous stroma. Except in the spleen, where the neoplastic elements appeared to have formed metastases along the trabeculæ in the substance of the organ, the serosa was the only tissue involved. In all situations frequent mitotic figures were seen.

After discussing the nomenclature of neoplasms based on the histogenesis of tumour-cells, the author arrives at the conclusion that the nodules described by him can best be classified as *mesotheliomata* arising from the mesothelium of the peritoneum and spreading from organ to organ by contiguity. An identical condition described by Scott (1927) from a Gnu in the London zoo is cited.

14. A simple test for diagnosis of influenza.

P. GANGULI, Calcutta.

There are various febrile disorders of short or long duration which are difficult to diagnose during the first few days of the fever. In none of these febrile diseases, except *influenza*, the pigmentary function of the liver is disturbed. Advantage has been taken of this observation, extending over a number of years in diagnosing influenza, differentiating it from various other febrile diseases. A pathological quantity of urobilin

and urobilinogen can be demonstrated in every case of influenza patients within two days of the attack, persisting for several days in complicated cases.

15. Chemical and pharmacological examination of some poisonous plants of India.

R. N. CHOPRA, J. K. LAHIRI *and* others, Calcutta.

The following four plants were studied: *Barringtonia acutangula*, *Rhododendron campanulatum*, *Anemone obtusiloba*, and *Holigarna arnottiana*. From the fruits of *B. acutangula*, a saponin was isolated and purified. The pharmacological action of the saponin was studied on fishes and it showed that the poisonous action of the plant on fishes could be accounted for by the presence of the saponin isolated. From the leaves of *R. campanulatum*, a very small quantity of 'andromedotoxin' was isolated and identified by its chemical properties as well as by its pharmacological action on the circulatory and respiratory systems of cats. The poisonous action of the plant on animals can be ascribed to the presence of andromedotoxin. By the steam distillation of the leaves of *A. obtusiloba*, a substance was isolated in very small amounts, the material not being very fresh, which responded to the chemical tests of 'anemonin', and the poisonous action of the plant can be ascribed to this. From *H. arnottiana*, nothing could be isolated which can account for the so-called blistering action reported by local people.

16. Chemical and pharmacological examination of *Skimmia laureola*.

R. N. CHOPRA, R. G. CHATTERJEE, J. S. CHOWHAN, *and* S. GHOSH, Calcutta.

The leaves of this Indian species was examined for its constituents. An alkaloid was isolated which was shown to be identical with Skimmianine found in *Skimmia japonica*. The presence of the glucoside found in another species could not be established. When injected into the lymph sac of a frog, the solution of skimmianine caused a severe irritation of skin glands, shrinkage of the skin, crossing of the legs, inability of movements or correction of position and rapid breathing followed by gasping and asphyxia. Injected intravenously into cats, it produced a sharp fall followed immediately by a maintained rise of blood pressure. When perfused into isolated mammalian hearts in small doses it produced a slight increase in the rate and amplitude of the beats, while bigger doses produced an irregularity and missing of beats. The heart stopped in diastole. Intestines showed a slight increase in volume and involuntary muscles showed a slight increase in tone. The alkaloid appears to produce a depression of the higher centres and death is due to its toxic action on the unstriped muscles.

17. The action of ajmaline on nerve impulses from sensory end organs in the muscle.

R. N. CHOPRA, N. DAS, *and* S. MUKHERJEE, Calcutta.

The action of ajmaline, the active principle of *Rauwolfia serpentina*, on the discharge frequency of nerves has been studied with nerve muscle preparations consisting of the toe muscle and the peronial nerve of frogs of the species *Bufo melanostictus* with the help of an oscillograph. Ajmaline in very low concentrations, 1 in 2,00,000, was found to increase the discharge frequency in many cases while with concentrations of 1

in 1,00,000 or still higher the frequency was found to decrease till at last at a certain concentration, viz. 1 in 100 no discharge was found to pass along the nerve fibre. The action was very prominent in the case of transected nerves where only a small number of fibres remained intact and the rest were destroyed. Such effect on the nerve was evident not when the nerve was bathed in ajmaline solutions but only when the muscle connected with it was similarly treated. This is suggestive of the fact that the alkaloid, ajmaline, probably does not act upon the nerves directly but through their end organs in the muscle. The nature of action resembles curare, strychnine, etc.

18. A recording out-flow meter. (A demonstration.)

S. W. Hardikar, Hyderabad (Deccan).

The instrument consists of two parts: (1) an adjustable automatic out-flow meter, and (2) the recording arrangement.

(1) The out-flow meter works on the principle of the Siphon, the instrument emptying itself when the fluid in it rises to a pre-determined level which is, however, adjustable, thus varying the amount of fluid discharged at each operation.

(2) The recording is done by means of the two-tambour method. The out-flowing fluid falls on the flattened end of the lever of one tambour and the impact is communicated by air to the writing lever of the other tambour.

The advantages claimed are:

(1) Ease of operation and adjustment;
(2) freedom from electrical contacts, and most important of all;
(3) very short working distance. This makes the instrument suitable for introduction into a closed circuit experiment on cardiac output when the volume of drug solution under investigation is desired to be kept at a minimum.

19. Cholesterol and lecithin in malaria.

N. D. Kehar, Kasauli.

Systematic investigation has been made of the variations of cholesterol content of plasma and whole blood during various stages of the human and monkey malaria.

Relationship of lecithin with cholesterol both in plasma and blood has been investigated. The influence of cholesterol feeding on the severity of infection and also on the onset of hæmoglobinuria has also been studied.

20. Significance of florence test for seminal stains.

K. N. Bagchi, Calcutta.

The Florence test for detection of seminal stains is of recent origin and of great importance in medico-legal investigations. It depends on the presence of free choline and formation of choline periodide crystals with iodine.

Lately, in a case of aspermia (semen having no spermatozoa), the Florence test was found strongly positive with a fresh as well as a decomposed specimen proving that the presence of spermatozoa is not necessary to produce the characteristic choline periodide crystals of a positive Florence test. The leucorrhœal discharge (specific and non-specific), pus from other sources, blood, sputum, fecal stains, *pan*-juice, etc., which are likely to be found in clothes received in such cases do not give a positive reaction. If the garments containing seminal stains even in well-defined cases are not thoroughly dried in air and are packed while the stains are still moist specially during the wet months, the spermatozoa become disintegrated,

probably by bacteria, beyond recognition but the choline for the Florence test is not affected at all. A positive Florence test is therefore a proof positive for seminal stains. The negative reaction, on the other hand, does not prove its absence. In some negative cases, prolonged search has revealed spermatozoa and in some cases an entire spermatozoon has been detected. The choline, if esterified, or in the presence of alkalis does not readily give the characteristic crystals. The presence of various unknown dirty substances in the garments of people usually involved in these cases is likely to affect choline in such a way as to prevent the formation of choline periodide and to give a negative Florence test. The concentration of choline and also of iodine in the reacting solutions is an important factor in producing the crystals. The hydrolysis of the aqueous extract of the stains with a few drops of N/10 NaOH and subsequent acidification with N/10 HCl is sometimes useful in getting positive reaction with stains in very dirty garments.

A positive Florence is therefore conclusive and does not require any search for spermatozoa for giving a positive opinion while a stain with negative Florence should be carefully treated repeating the test after hydrolysis. A thorough microscopic examination for spermatozoa is necessary in such cases, without which a negative opinion is not justified.

21. Dissemination of anthrax infection through dirty stagnant pools.

R. N. Naik, Bombay.

Anthrax which is enzootic among domesticated animals in various parts of India is not of uncommon occurrence during the early summer when green grazing is not available. Draught animals also suffer from the disease ; but the source of infection during this season was not known. Investigation was, therefore, carried out in certain outbreaks of Anthrax which occurred during the last summer in the Ratnagiri District with the result that dirty stagnant pools formed in the river bed were found to be the actual source of infection. A virulent strain of *B. anthracis* has been recovered from a sample of water from one of such pools.

22. Contagious bovine abortion in India and its significance to public health.

R. N. Naik, Bombay.

The incidence of Contagious Bovine abortion due to *B. abortus* Bang in India has been reviewed. The disease as it occurs in India is described and the danger of developing undulent fever by human beings through handling of infected animals or consuming infected milk and milk products is emphasized.

23. Two cases of naturally acquired tuberculous infection in cows in India caused by the human tubercle bacillus.

M. B. Soparkar, Bombay.

In a paper read before this Congress in 1931 findings were reported of examination of over 1,100 carcases of cattle slaughtered in the Punjab which had resulted in the discovery of 255 animals or over 22 per cent. with gross lesions of tuberculosis. Such gross lesions in Indian cattle have previously been shown by the author to be caused by virulent bovine bacilli.

A large number of specimens showing no definite naked eye or bacillary evidence of tuberculosis but presenting a suspicious appearance were also collected from the Ferozepur abattoir and examined by further animal tests. Out of over 70 specimens examined, in only two instances the inoculated animals developed tuberculous lesions—the rest being negative —and strains were isolated from these specimens. A study of these strains showed that both were of the human type. This type of natural infection is considered very rare among cattle and the finding indicates that such infection of cattle from man may take place and the habits of the people in the Punjab and their association with cattle would support the view. Further, the relation of this finding to the disconcertingly high proportion of tuberculin reactors found by the author among indigenous cattle is discussed.

24. Prevalence of tuberculosis among animals other than domestic cattle in India.

M. B. Soparkar, Bombay.

This paper deals with investigation of cases of tuberculosis found among Sambars in the Bombay Zoological Gardens. The carcass of a sambar (*Cervus affinis*) that had died in the gardens when sent for examination was found to have died of extensive tuberculosis affecting the lungs and the pericardium. A strain was isolated from the lesions and it proved to be of a virulent bovine type. The enclosure in which this animal was kept contained several other sambars which were suspected to have acquired the infection and they were subjected to the tuberculin test. Seven out of nine sambars tested gave a positive reaction indicating infection. Three of them were subsequently destroyed and autopsy showed a few tuberculous lesions in one and only suspicious lesions in the other two. Nevertheless when material from these animals was inoculated into guinea-pigs all of them developed severe tuberculosis and the strains isolated from them were found to be of the bovine type of high virulence showing that the animals did not acquire the infection from the attendants or the visitors to the gardens but probably from other animals infected with bovine bacilli. A systematic survey of the prevalence of this infection among animals in the gardens would appear to be indicated.

25. A preliminary report on canine schistosomiasis in Madras Presidency.

M. A. Narayan Rao, Madras.

The first case of schistosomiasis in a dog in India was reported by Rao and Ayyer in 1935 and the present author records another case indigenous to Madras Presidency. This dog lived most of its life in Gudiattam, a village in the North Arcot District, where it was allowed to swim in ponds frequently. The clinical history of the case is that it developed repeated attacks of dysentery. The microscopical examination of the faeces revealed a large number of ova of schistosomes which closely resembled those of *S. suis* Rao and Ayyer, 1933. *S. suis* was discovered in pigs that came for slaughter in Madras from North Arcot District, hence it seems possible that many of the ponds in that district are infected and of the dog having picked up the infestation from one of these. It is not known if this schistosome is widely spread in India though there is evidence to show that it exists in the Central Provinces and Bengal.

A detailed description of the ovum and the miracidium is given in the paper. It is compared with that of some other species and the differences noted.

26. Mange affecting the horn of buffaloes.

R. N. NAIK, Bombay.

This disease condition has so far been investigated only in the Bombay Presidency. The disease as it occurs under natural conditions and the mange mite concerned are described.

27. Coccidiosis in crows.

R. N. NAIK, Bombay.

Doyle's disease which is a common fatal disease of fowls in India is believed to attack crows and to cause high mortality among them. The writer therefore was on the look-out for a disease in crows and actually found out one in a part of the Bombay City. The symptoms in this disease resembled those of Doyle's disease in some respects but on further investigation and biological experiments the disease was proved to be coccidiosis.

28. Field investigation of the problem of liver fluke infestation amongst cattle and sheep in Hyderabad State.

M. R. MAHAJAN, Hyderabad (Deccan).

This is a serious infestation of cattle and sheep in Hyderabad. Losses have been heavy particularly in the Nizamsagar canal area which is of recent development, and Pocharam lake and canal area of Medak District. The Nizamsagar canal runs through three taluqs of Nizambad District. So far two of these have been surveyed. The infestation of animals and the existence of molluscs in tanks and streams have been ascertained. The fluke responsible is *Fasciola gigantica* and mollusc hosts seen are *L. acuminata* (mostly), *L. luteola* and *Indoplanorbis exustus*. The clinical cases are usually seen during winter and spring.

As to control measures, the treatment of clinical cases with carbon tetrachloride in capsules has been adopted and to control the intermediate host—copper sulphate in a bag was placed in the stream in two villages experimentally. The results obtained from these measures appear to be encouraging but our main problem is to effect control over a large area fed by the canal 96 miles in length.

A severe outbreak recently occurred amongst sheep kept at the Government Farm, Hingoli. Probably the disease was imported through sheep brought from Karnal. But acute and chronic types of the disease were encountered. Treatment with liquid extract of malefern was not effective but carbon tetrachloride effected control. In addition, the sheep were watered from a well and not from the tank, which had become the source of infection, having plenty of moll host *L. acuminata,* and this prevented further infection.

29. The occurrence of spinose ear tick (*Ornithodorus megnini*) in India.

S. K. SEN, Muktesar.

On the 15th January, 1936, a consignment of ticks reported to have been collected *post-mortem* from inside the ears of an imported Australian horse, that had developed symptoms of inco-ordination of movement as a result of the infestation, was received at the Muktesar Institute for identification, from Saugor, Central Provinces. These on examination

proved to be the nymphs of *Ornithodorus megnini*, the well-known Spinose Ear Tick of America, the occurrence of which had not been previously recorded from India. Subsequent to this, three further consignments of the same species of tick were received for examination, two collected from imported Australian horses and one from an Indian mare. Two of the nymphs—a male and a female—were found moulted to the adult stage on the 2nd May and eggs were first seen on the 26th May and larvæ on the 18th July. On the 29th July, about thirty of the larvæ were introduced into the ear of a country-bred pony, a special device being adopted to prevent the ticks from escaping. The pony, however, did not develop any clinical symptoms as a result of the infestation during an observation period of 35 days. When the ear was examined at the end of this period, four of the larvæ were found to have changed to fully-engorged nymphs.

The manner in which *O. megnini* came to be introduced into India would appear to merit investigation, and in this connection three possibilities suggest themselves, viz. that it may have been brought (1) with artillery mules coming from North America; (2) from Australia, where, however, *O. megnini* is not known to occur; (3) with stock coming from South Africa, where the tick was first seen in 1898. It would also be of interest to inquire into any possible connection between such tick infestation and some cases of equine paraplegia and into the extent to which the tick has established itself as a pest of domestic animals in this country.

30. Experiments on the transmission of rinderpest through the agency of *Stomoxys calcitrans*.

S. K. Sen *and* Abdus Salam, Muktesar.

In a previous communication published from this Institute, Bhatia (1935) reported having obtained negative results in every one of a series of four experiments carried out by him to test the possibility of rinderpest being transmitted by *Stomoxys calcitrans*, the number of flies used by him in these experiments ranging from 3 to 14. It was, however, considered desirable to carry out more extensive trials with this species of fly before completely eliminating it as a possible transmitter of the disease. Several hundred wild flies, divided into batches, were fed on bulls artificially infected with rinderpest and they were allowed to complete their feed on a healthy bull, the number of infective bites thus inflicted amounting approximately to 1,081 spread over a period of 32 days. The bull, however, did not develop the infection during an observation period of six weeks, at the end of which it was tested for immunity by the inoculation of virulent blood and it died after showing typical symptoms of rinderpest. A method is described for feeding, by the interrupted method, a large number of flies singly, within a limited period of time.

31. A piroplasm from the Indian cat.

M. Y. Mangrulkar, Muktesar.

In 1904 Lingard made the statement that, amongst other animals, cats in Bareilly (U.P.) were 'subjects of spontaneous piroplasmosis'. Since then only three other records of the occurrence of piroplasmosis in felines (Davis 1929, Wenyon and Hamerton 1930, and Carpano 1934) appear to have been made.

In the course of routine post-mortem examinations, the author had the opportunity of examining several feline carcasses, and in the present paper he reports from the blood of a debilitated cat a piroplasm which resembles morphologically the one described as *Babesia felis* by Davis from a Sudanese wild cat.

32. A study of the life-history of *Cotylophoron cotylophorum* (Fischoeder, 1901) Stiles and Goldberger, 1910, of Indian ruminants and a biological control to check the infection.

H. D. SRIVASTAVA, Muktesar.

The occurrence of epizootics of acute Amphistomiasis among sheep and goats in the United Provinces was responsible for undertaking an investigation into the life-history of a common Amphistome, *Cotylophoron cotylophorum*, of Indian ruminants. The eggs used in the experiments were obtained from specifically determined adult parasites and were incubated in water in glass dishes at room temperature. The eggs hatched in three weeks' time and the miracidia thus obtained were used in infecting laboratory-raised specimens of a common snail, *Indoplanorbis exustus*. The snails were raised from eggs in glass aquarium in the laboratory. The developmental stages of the parasite inside the molluscan host have been studied in detail. The cercariæ, which belong to the 'Pigmentata Group', began to escape from the snails in regular streams, specially when the aquarium containing the snails was kept exposed to bright sunlight for some time, about 16 days after the miracidial infection. After a brief active period, hardly an hour, the cercariæ cast off their tail and encyst on any kind of vegetation provided, in this particular experiment leaves of banian tree, or on the walls of the container. The encysted cercariæ remain alive and infective for about four months. A number of leaves bearing encysted metacercariæ were fed to two out of four clean laboratory-raised kids, the other two remaining as control. Four months after infection with metacercariæ the animals showed symptoms of acute amphistomiasis to which one of the animals succumbed. On post-mortem examination, numerous immature amphistomes were found embedded in the wall of the duodenum and intestine. The other infected and the two controls were slaughtered six months later; adult parasites were obtained from the rumen of the first, while the last two were free from infection. Experiments were repeated and it was established that the Amphistomes are pathogenic only in their immature stages which are passed in the intestine. Later on the parasite migrates upwards and comes to lodge in the rumen as a non-pathogenic adult. It has been proved experimentally that the snails when they are infected with an aquatic Oligochæte, *Chœtogaster limnœi*, cannot be infected with trematode larvæ while the same snails when free from *Chœtogaster limnœi* readily yield to miracidial infection. Subsequent field surveys confirmed the experimental findings in the laboratory.

33. A study of the life-history of a common tapeworm, *Mesocestoides lineatus*, of Indian dogs and cats.

H. D. SRIVASTAVA, Muktesar.

The aberrant family, Mesocestoididæ, of Cyclophyllidean cestodes contains only one genus with two valid species, *Mesocestoides lineatus* and *M. perlatus*. The genus differs from all the members of the Cyclophyllidea in having divided yolk glands, genital pore situated on ventral surface, thick-shelled egg capsules containing eggs and Pleurocercoid type of larva (Tetrathyridium). Though a vague suspicion existed since 1874 when Leuckart pointed out the similarity of scolices of 'Cysticerca' from the abdominal cavity of lizards with '*Taenia litterata*' of foxes, it was Henry (1927) who for the first time proved that Tetrathyridia are the larvæ of *Mesocestoides* sp. Schwartz (1922), Joyeux and Baer (1932) and Witenberg (1934) obtained adult worms by feeding Tetrathyridia from a number of vertebrates to dogs and cats. The author found a large number of Tetrathyridia encysted in the serous coat and liver of a local snake. The larvæ were highly contractile and measured 1·5 to 4 mm. in length.

The broadly rounded anterior end bears an invaginated scolex with four unarmed suckers. The larvæ were fed to two clean, parasite-free jackal pups, both of which died in 16 to 17 days. On post-mortem examination, they were found heavily infected with a very large number of specimens of *M. lineatus*. Tetrathyridia similar to the above have subsequently been obtained from local lizards and wild rats. Tetrathyridium is the second stage larva of the tapeworm. An attempt was made to discover the primary larval stage by feeding eggs of the worm to white mice, which proved abortive, for Oncospheres did not develop. This failure confirms the view of Henry and Witenberg that Tetrathyridium develops not from egg but from a primary stage occurring probably in some lower animal.

34. Studies on the helminth parasites of Indian poultry. Part I. A new fluke from the oviduct of fowl.

H. D. SRIVASTAVA, Muktesar.

Hyeronymi and Szidat (1921) were the first to report serious losses amongst chickens due to a fluke disease caused by *Prosthogonimus intercalandus* Szidat. Subsequently not only several cases of this disease have been reported from different parts of the world but also a number of new species have been added. The genus is now considered to be the most pathogenic trematode of poultry. The worms, which usually live in the Bursa fabricii, enter the oviduct in laying birds and are responsible for acute inflammation resulting in the production of abnormal eggs and discharge of albumen. Owing to irritation, retroperistaltic movements are set up in the oviduct causing broken yolks, albumen and parasite material to enter the peritoneal cavity, setting up acute peritonitis. The parasites are sometimes included in the eggs as happens with *P. ovatus.* So far the occurrence of this genus is not known in any Indian bird. Through the courtesy of Mr. S. Ganapathy Iyer the author received a number of fowls which had succumbed to Doyle's disease and Fowl-pox, for examination. From the oviduct of two fowls three specimens of *P. indicus*, n.sp., were recovered. One of the birds was heavily infected with *Amoebotœnia sphenoides* also. The Indian form differs from *P. pellucidus* in a number of important characters enumerated in the paper. The occurrence of the parasite in wild Indian birds, which probably act as reservoir, is also reported. A revision of the genus is given.

35. Studies on the helminth parasites of Indian poultry. Part II. The occurrence of gape-worms in fowls.

H. D. SRIVASTAVA, Muktesar.

The occurrence of gape-worms, *Syngamus trachea*, has been reported from fowl, turkey, goose, pheasant and a fair variety of wild birds in various parts of the world. It is more common in young birds than in adults. It causes the condition known as 'Gapes'. In the Fauna of British India, Nematoda, Vol. I, 1936, Baylis remarks, 'The parasite is widely distributed throughout the world but the only record from the Indian region appears to be from the fowl at Colombo, Ceylon (v. Linstow)'. The author examined post-mortem about a dozen chickens at Bareilly in 1935 and recovered four specimens of worm in copula from two of them. One bird was found to harbour specimens of *Catatropis indicus* Srivastava, 1935. The Indian gape-worms show slight differences from *S. trachea* which are pointed out in the paper. The differences are considered to be only variations within the species. The occurrence of gape-worms in Indian snipes, which apparently show no symptoms, is recorded.

36. Studies on the helminth parasites of Indian poultry. Part III. The occurrence of two spirurid stomach-worms in fowls.

H. D. Srivastava, Muktesar.

In this paper the author records for the first time the occurrence of members of two genera of spirurid worms, *Acuaria* Bremser, 1811, and *Tropisurus* Diesing, 1835 (*Tetrameres* Creplin, 1846) in the stomach of fowls in India. Representatives of the genus *Acuaria* were first met with in the soft nodules in the musculature of the gizzard of a fowl from Delhi and a second time in a local fowl. The parasites are white in colour, slender and measure about 1″ in length. They burrow through the horny lining of the gizzard producing soft nodules in the musculature. On careful examination the lining of the gizzard reveals the presence of small, round holes. The paper includes a description of the parasite together with its specific features.

A single female specimen of the genus *Tropisurus* was received through the courtesy of Mr. Mangrulkar who had dissected it out from the proventriculus of a fowl. The parasites of this genus show extraordinary sexual dimorphism. The female, after copulation, swells up into a spherical shape, while the male remains slender throughout its life. Though the parasite is very common, according to Mr. F. Ware, in birds in Southern India, it has not been recorded from this country so far.

37. A few species of anoplocephalid tapeworm of the genus *Bertiella* from a domestic pigeon.

H. D. Srivastava, Muktesar.

The genus *Bertiella* Stiles and Hassal, 1912, is usually parasitic in the intestine of primates, though cases of infection have also been reported in dogs, rodents and marsupials. Nine cases, four from India, of human infestations with this tapeworm are on record. According to Cram, 1928, three species of the genus are parasitic in birds. In this paper the author gives an account of the only representative of the genus in an Indian bird. The validity of the different species of the genus is discussed.

38. The occurrence of an interesting nematode in the lungs of an Indian cat.

H. D. Srivastava, Muktesar.

The hitherto known nematodes which occur in the lungs of domesticated carnivores belong to the genus *Eucoleus* (Family Trichinellidæ), and three genera—*Aelurostrongylus*, *Angiostrongylus* and *Oslerus* of the family Metastrongylidæ. The genus *Eucoleus* occurs free in the trachea of dogs and cats while *Aleurostrongylus* lives in the pulmonary vessels of cats and *Angiostrongylus* in the pulmonary artery and right ventricle of dogs. The only lungworm so far known from domestic carnivores in India is *Oslerus osleri* of uncertain affinities occurring in nodules in the trachea and bronchi, rarely lungs, of dogs. During a routine examination of cats the author discovered a large number of white, slender worms in the bronchi of a cat at this Institute. Besides these lungworms the cat was found heavily infected with *Mesocestoides lineatus* and *Echinochasmus perfoliatus*. The lungworms on examination proved to be very interesting and different from the above-mentioned genera. The paper includes a description of the worms and a discussion on their systematic position.

39. The occurrence of *Paragonimus westermanii* in the lungs of cats in India.

H. D. Srivastava, Muktesar.

The well-known lung-fluke, *Paragonimus westermanii*, originally described from the lung of a tiger, is now known to occur in the lungs, rarely in brain, spinal cord and other organs of pig, dog, cat, goat, cattle, man and wild carnivores. Surveyor (1919) recorded an imported case of *Paragonimiazis* in a Chinaman in Bombay. Gulati in 1926 described *P. edwardsi*, n.sp., from the lungs of *Paradoxurus grayi*. Rao in 1935 recorded the occurrence of *P. westermanii* in the lungs of dogs in Madras. The author gives an account of the parasite which he has obtained from the lungs of a cat at Muktesar. The validity of the different species of the genus is also discussed.

40. The occurrence of an unrecorded filarid nematode, *Onchocerca cervicalis* Railliet and Henry, 1910, in the ligamentum nuchæ of horses in India.

H. D. Srivastava, Muktesar.

Railliet and Henry in their paper on the classification of the genus *Onchocerca* Diesing, 1841, published in 1910, established a new species, *O. cervicalis*, which according to them was very common in France. Subsequently this nematode worm has been reported from equines in a number of countries,—Australia, England, United States of America, and Africa. It has also been suspected to be the cause of poll evil and fistulous withers. The occurrence of this worm in the ligamentum nuchæ of Indian horses has not been known so far. The author recovered pieces of the worm from the ligamentum nuchæ of three horses suffering from lichen tropicus. The worm lies intricately coiled in the muscles of the ligamentum nuchæ. Small, hard, nodules have been found attached at one end of the worm. The specimens of the worm studied by the author were first collected by Capt. S. C. A. Datta from cases of lichen tropicus of which it is suspected to be the causative agent.

41. An unrecorded spirurid worm, *Rictularia cahirensis* Jagerskiold, 1904, from the intestine of an Indian cat.

H. D. Srivastava, Muktesar.

The first specimens of this parasite which the author received for study were through the courtesy of Mr. Abdussalam of the Lahore Veterinary College. Subsequently the parasite has proved to be of very common occurrence in the local cats, the frequency of infection being nearly 75 per cent. The small worm has a very characteristic appearance. Its cuticle is armed, at least in the anterior region, along the sides with two subventral series of large, flattened, comb-like spines which become sparse towards the hinder end. The Indian form differs from *R. cahirensis* in certain details which are pointed out in the paper. Encysted nematode larvæ, suspected to be of this parasite, have been found in the serous coats of local lizards. The only record of the occurrence of this parasite in India is from a civet cat.

42. The morphology and systematic relationships of a new parasite—*Waretrema piscicola*—Gen., et sp., nov., referable to a new family—Waretrematidæ N. Fam., of Digenetic Trematodes.

H. D. Srivastava, Muktesar.

But for the account of six new flukes published by the author in the *Proc. Nat. Acad. Sci., India,* Vol. VI, (1936) nothing is so far known

of the trematode parasites of Indian marine food fishes. In this paper are described in detail the morphology, anatomy and systematic relationship of an interesting trematode for which it is not only necessary to create a new genus but also a new family. The account is based on a study of more than 100 specimens obtained from the gut of *Trichiurus mutieus* Gray. Body medium-sized, sub-cylindrical, spiny. Oral sucker subterminal with a crown of six conical papillæ; acetabulum slightly larger than oral sucker. Prepharynx, pharynx and oesophagus present; cæca small, saccular, reaching up to anterior end of ovary. Testis single, median, post-equatorial. Cirrus sac elongated bulb-shaped, enclosing vesicula seminalis interna, pars prostatica, prostate glands, ductus ejaculatorius and strongly developed metraterm containing eggs. Ductus ejaculatorius joins metraterm at about half its length enclosed in the cirrus sac. Ovary spherical, pretesticular. Receptaculum seminis present. Vitellaria consist of about 12 long finger-shaped lobes arranged around the testis. Eggs numerous. Excretory bladder Y-shaped.

The parasite combines in itself some of the characters of Monorchidæ and of papillose Allocreadidæ, but in most of its characters, specially in its terminal genital ducts, it is unique amongst the digenetic trematodes. The affinities of the parasite, which is named in honour of Mr. F. Ware of Imperial Veterinary Research Institute, Muktesar-Kumaun, are discussed in detail.

43. Studies on the amphistomatous parasites of Indian food fishes. Part I. Two new genera of amphistomes from an Indian fresh-water fish, *Silundia gangetica*.

H. D. Srivastava, Muktesar.

The morphology, anatomy and relationships of three species of Amphistomes, referable to two new genera of the sub-family Cladorchinæ, obtained from one of the biggest fishes in the Ganges and Jumna at Allahabad have been studied. *Nicollodiscus gangeticus,* gen. et sp. nov., is rather a rare parasite inhabiting the large intestine of about 5% hosts. The number in a single host varies from 2–30. Hitherto 15 genera of Amphistomes are known from fishes—9 belonging to the subfamily Cladorchinæ, family Paramphistomidæ, 1 to Opistholebetidæ, 3 to Gyliauchenidæ and 2 to Cephaloporidæ. *Nicollodiscus gangeticus* is assigned to the sub-family Cladorchinæ. It differs from all the genera of Amphistomes from fishes in having a conical body with a broad base, the broad acetabulum studded with numerous conspicuous papillæ, nearly symmetrical, extracæcal, equatorial and deeply lobed testes, extent of vitellaria and the presence of a wide genital sucker in level with the pharynx.

Orientodiscus jumnai, gen. et sp. nov., occurs in the rectum of about ten per cent. of its hosts. The main features of the genus are its unique excretory system with the cornua forming characteristic loops round the intestinal cæca and the character and disposition of vitellaria. *O. labatum,* n.sp., differs from the type species mainly in the lobed character of its gonads.

A brief résumé of literature on the genera of the sub-family Cladorchinæ and a key to its genera are included in the paper.

44. Studies on the family heterophyidæ Odhner, 1914. Part II. Parasites belonging to a new sub-family Polyorchitreminæ from the gut of an Indian fresh-water fish.

H. D. Srivastava, Muktesar.

The morphology, anatomy and systematic relationship of an interesting trematode, *Polyorchitrema piscicola,* gen. et sp. nov., parasitic

in the gut of *Eutropicthys vacha* at Allahabad have been studied. Body muscular, spindle-shaped, smooth. Oral sucker small, subterminal; acetabulum twice the size of oral sucker, poorly muscular, lying completely submerged in ventrogenital-sinus—a saccular ventral pouch close behind the intestinal bifurcation and completely enclosing a poorly muscular acetabulum, gonotyl, and opening of the ductus hermaphroditicus and communicating to the exterior by a small, triangular pore close behind intestinal bifurcation. Prepharynx, pharynx and oesophagus present; cæca long. Excretory bladder Y-shaped. Testes numerous, intercæcal, in posterior third of body. Vesicula seminalis long, sinuous; pars prostatica, prostate glands, ductus ejaculatorius and ductus hermaphroditicus present. Ovary lobed or entire, pretesticular. Receptaculum seminis present. Mehlis gland dorsal to ovary. Vitellaria follicular, in grape-like lateral bunches from behind acetabulum to hinder end. Uterus pretesticular, eggs numerous.

The parasite is unique amongst heterophyids in the peculiar character of its ventro-genital sinus with its enclosed organs; in having a large number of testes, in the position and extent of vitellaria and the extent and configuration of uterus, besides minor differences. A diagnosis of the genus is given.

45. The morphology and systematic relationship of a new parasite *Mehracola ovocaudatum*, gen. et sp. nov., (family Acanthostomidæ) from an Indian marine food fish.

H. D. Srivastava, Muktesar.

The paper includes a detailed account of a new distome of the family Acanthostomidæ. Two mature specimens of the parasite were obtained from the intestine of a fish examined at Karachi in 1936. Body fusiform, spiny. Suckers spherical, oral sucker subterminal; acetabulum larger than oral sucker, situated at about anterior third of body. Prepharynx long, pharynx and oesophagus small; cæca stop a little in front of posterior end. Testes two, reniform with lobed outer margins, extracæcal, about the end of middle third of body. Ovary pretesticular, follicular, follicles arranged in a median spherical mass. Vesicula seminalis a broad coiled tube with constrictions, extending from ovary to a little in front of acetabulum. Vitellaria profusely developed, pretesticular, from a little behind intestinal bifurcation to anterior ends of testes, not meeting measially. Uterus well developed, arranged in transverse ascending and descending coils in postovarian region; eggs numerous, with long polar filament at one end. Excretory bladder Y-shaped. In the topography of gonads, excretory bladder and configuration of uterus *Mehracola* resembles *Paracryptogonimus*, but it differs from the latter in the absence of oral spines, shape of testes, anterior and internal extent of vitellaria, extent of vesicula seminalis, absence of genito-acetabular-depression and the presence of a polar filament in the egg. The parasite is named in honour of Professor Dr. H. R. Mehra.

46. The morphology and systematic relationship of two new distomes of the family Haplosplanchnidæ Poche, 1926, from Indian marine food fishes.

H. D. Srivastava, Muktesar.

Loss in 1902 created the genus *Haplosplanchnus* for *H. pachysomus* Eysenhardt. 1829. The family Haplosplanchnidæ so far contains only one genus and one species. In the summer of 1935 the author collected from the gut of two different species of marine fishes at Puri two new members of this family. *Haplosplanchnus purii*, n.sp., has the generic characters of the type species but differs from the latter in the shape and

size ratio of suckers, length of intestinal cæca, more caudad position of gonads, position of receptaculum seminis and the restricted development of vitellaria.

The other parasite, *Laurea caudatum*, gen. et sp. nov., is comparatively less common than *H. purii*. It has a very characteristically triangular body which is drawn out into a long semi-spirally curved tail. Oral sucker terminal; acetabulum long, peculiarly bottle-shaped. Prepharynx, pharynx, and oesophagus present; cæca small, saccular. Testes single; vesicula seminalis, pars prostatica and prostate glands well developed; ductus hermaphroditicus present. Ovary pretesticular receptaculum seminis present. Vitellaria poorly developed. Eggs numerous containing miracidia. Excretory bladder Y-shaped. The main features in which *Laruea* differs from the type genus are the peculiar shape of body with a curved tail, a long bottle-shaped acetabulum and position of gonads. The parasite is named in honour of Dr. G. R. La Rue, the well-known American helminthologist.

47. The occurrence of coccidia in dogs at Bombay.

K. R. S. Aiyar, Bombay.

The paper records the occurrence of coccidia (Isospora rivolta) and the affection coccidiosis caused in dogs at Bombay. The identification was arrived at on the lines suggested by 'Wenyon'. Coccidia have always been found in the faeces along with other intestinal parasitic ova. The anthelmintic treatment of other intestinal parasites alone only were adopted leaving the Coccidia untreated. It appears that spontaneous recovery does take place.

SECTION OF PHYSIOLOGY

President :—LT.-COL. S. L. BHATIA, *M.C.*, M.A., M.D., F.R.C.P., F.R.S.E., I.M.S.

Presidential Address

PHYSIOLOGY IN INDIA

For a scientific worker in India to preside at a Section of the Indian Science Congress is indeed a signal honour. I wish to express my profound appreciation and gratitude for the great honour done to me by my colleagues in inviting me to preside over the Section of Physiology this year.

This Section is still in its infancy. To-day, in fact, we celebrate its first anniversary. Its inception last year was a recognition of the fact, that the Science of Physiology existed in India, and that the special workers in this field had achieved enough importance to deserve a separate Section of their own. This recognition, tardy and belated though it be, implies that Physiology is not to be regarded merely as a handmaiden of Medicine, but as an independent science of fundamental importance. This marks a distinct and vital stage in its history in India, and makes one naturally think of its past and its future in this country. I have, therefore, chosen 'Physiology in India' as the subject of my address. To trace successfully the evolution of any science in any country is a difficult task; but to trace the evolution of Physiology in India is all the more difficult, in view of peculiar conditions here. In the course of this address, I shall content myself by dealing with certain factors only, which are of interest to us, and shall undoubtedly omit much, which might have made less sketchy a sketch necessarily imperfect.

PHYSIOLOGY IN INDIA : THE PAST.

In India, as elsewhere, the history and growth of Physiology are inseparably connected with those of Medicine. Indeed, Medicine is the mother of all branches of Natural Science. Chemistry, Physics, Botany, Zoology, Anatomy, Physiology, Pathology, and Bacteriology have all arisen from Medicine. Mankind is always in search of better and better means for the maintenance of health and cure of disease. This has resulted in new lines of thought and new methods of work from time to time, thus creating new sciences. Medicine has been practised and

taught in India from times immemorial. The system of Medicine which is indigenous to the soil is the Ayurvedic. Subsequently with the advent of the Moslems, the *Unani* or the Græco-Arabian system was introduced. This was based on the science of Greece and Egypt and was developed under the enlightened patronage of the Khalifas of Baghdad. The principal service of Islam to Medicine was the preservation of the Greek culture. These two systems of Medicine were the only ones taught and practised in India up to the time it came into contact with the nations of the West. They still exist and command much influence. In any system of Medicine, some hypothesis as regards the normal functions of the different organs of the body is essential, in order that morbid processes occurring in different diseases may be given a rational explanation. You are no doubt aware, that the Humoral Physiology of the Ayurvedic Medicine presupposes three principal 'humours' or fluids in the body, namely 'Vata' or wind, which has its seat between the feet and the umbilicus; 'Pitta', between the umbilicus and the heart; and 'Kufa' between the heart and top of the head. Health is associated with the normal condition of these humours; disease with their derangement. The Unani system was noted specially for its chemistry, which had its origin in Arabia. The processes of distillation, filtration, sublimation, water baths, etc. were introduced there. The Physiology of this system was mainly that of Galen. Charaka and Susruta, the great physicians of the ancient Ayurvedic Medicine, and Rhazes and Avicenna, the famous Persian physicians who practised the Unani system, are the great master-minds of Medicine of the past, and rank with Hippocrates the famous Greek physician of antiquity. It is not my purpose here to-day to discuss and appraise the Physiology contained in the ancient systems of Medicine in India. All I wish to point out is that the theories and dogmas held by the ancients are not to be despised. On the contrary, their achievements deserve praise. They served their purpose admirably in their day. Each age must make the best of the knowledge it possesses. Who can tell what our successors two thousand, or even two hundred, years hence will think of us for the views and dogmas, that we profess to-day?

It is more to my purpose to describe briefly to you the steps that led to the introduction of Modern Medicine and Physiology into India. This movement started in the early part of the 19th Century. At this time, instruction in Ayurvedic and Unani systems of Medicine was imparted in the Sanskrit College and the Madrassa in Calcutta. It was however in 1822, that the first Medical School was established in that city. A similar Medical School was started in Bombay in 1826. It functioned for 6 years and was abolished in 1832. Credit is mainly due to Lord William Bentinck, the Governor-General, for initiating

higher medical education in India. He appointed a Committee in 1833 for improving the Medical School in Calcutta, and the education imparted there. The members of this Committee were Surgeon John Grant, Apothecary (Medical Store-keeper) to the East India Company; J. C. C. Sutherland, Esq., Secretary to the Education Committee; C. E. Trevelyan, Esq., Deputy Secretary, Political Department; Assistant Surgeon Spens of the Bodyguard; Assistant Surgeon M. J. Bramley, Assistant Marine Surgeon, and Babu Ram Komal Sen. The deliberations of this Committee have had a most profound effect on the future course of medical education in India. In October 1834, the Committee submitted a lengthy report and made several recommendations for the improvement of the Calcutta Medical School. It is interesting to note that on one point the members of the Committee were divided, namely whether the instruction should be imparted in an Indian Vernacular or in English. The anglicists finally prevailed over the orientalists. These recommendations were approved. The result was that the Medical School was abolished, and the medical classes at the Madrassa and the Sanskrit College were also done away with. The old order changed yielding place to new. The foundation of a new Medical College of Bengal was sanctioned in 1835. The original staff of the College consisted of Drs. M. J. Bramley and H. H. Goodeve.

In Madras, when Sir Frederick Adam was Governor, a Medical School was established in 1835. It was of the same Standard as the Medical School founded in Calcutta in 1822, rather than the College founded in 1835. The original staff consisted of Surgeon William Mortimer and Assistant Surgeon George Harding. In 1847 the Madras Medical School was raised to the Standard of the Medical Colleges in Calcutta and Bombay, but its name remained unaltered until 1st October, 1850.

In Bombay, it is to Sir Robert Grant, who was Governor from 1835 to 1838, that the credit for the introduction of higher medical education is entirely due. Soon after he became Governor he directed his attention to this subject. In 1837 the Medical and Physical Society of Bombay was organized and in the same year the Government directed its Managing Committee to look into the subject of medical education. A former Medical School, one of the earliest of its kind in India, had flourished here for 6 years and then abolished, as already mentioned, in 1832. This was rather disheartening, and so the movement for the establishment of a new institution moved rather cautiously and slowly, but surely. After consulting various bodies, Sir Robert Grant wrote to Calcutta, the then Capital of India, advocating enthusiastically the establishment of a Medical College in Bombay. The proposal was approved by Lord Auckland's Government. But before this information

reached Bombay, Sir Robert Grant died on 9th July, 1838. At a public meeting held on 28th July, 1838, at the Town Hall in Bombay, it was decided that as a mark of respect to the memory of the late Sir Robert Grant and in gratitude for his public services a Medical College so ably planned by him be established and bear his name. The institution was thus named *Grant Medical College.* The cost of the building was defrayed equally by public subscription and by contribution from the Government. The foundation-stone of the edifice was laid on 30th March, 1843, by the Lord Bishop of Calcutta. It was completed in October 1845. The College is associated with the Jamsetjee Jeejeebhoy Hospital, named after Sir Jamsetjee Jeejeebhoy who offered a sum of one lac of rupees, provided the Government contributed an equal sum, for the establishment of a Hospital. The foundation-stone of the Hospital building was laid on 3rd January, 1843, and it was opened for the reception of the sick in 1845. The College and Hospital being thus ready, instruction began in November 1845. The original members on the staff were Drs. Charles Morehead (the Principal), John Peet, and H. Girand. With this institution I have the honour of being associated for some years now. If I have described its origin at some length, my excuse is that I am better acquainted with it than with any other Medical College in India.

This is briefly the history of the establishment of the three oldest Medical Colleges in India, where the teaching of Modern Medicine and Physiology first started. Subsequently other Medical Colleges of a similar kind were established, namely the King Edward Medical College, Lahore (1860), King George Medical College, Lucknow (1912), Lady Hardinge Medical College, Delhi (1916), Carmichael Medical College, Calcutta (1916), Medical College, Vizagapatam (1923), King Edward Medical College, Patna (1925), Seth Gordhandas Sunderdas Medical College, Bombay (1926), and Medical College, Rangoon (1924).

There are Medical Colleges, besides, at Hyderabad (Deccan) and at Mysore, and numerous Medical Schools in all the Presidencies and Provinces of India. Time would not permit me to narrate the interesting history of all these institutions. But one thing is certain. With the increase in the number of Medical Colleges and Schools there has resulted a marked expansion of medical education throughout the country in recent years. And side by side with this, the knowledge of Physiology has also spread. In most of the Medical Colleges in the past, the Chair of Physiology was often held by one who also taught some other subject, such as Medicine, Pathology or Anatomy. Subsequently it was made an independent Chair. In later years, it has been made a whole-time Chair, the Professor being debarred from medical practice.

In Bombay, Physiology was originally known as 'Institutes of Medicine', a designation by which it was known till lately in the Scottish Universities. It was taught at first by Dr. Charles Morehead, the first Principal of the College, who was Professor of the Institutes and Practice of Medicine.

We have had some excellent and renowned teachers of Physiology in India in the past, such as Dr. Charles Morehead, Col. Meyer, and Col. Rose Hutchinson in Bombay, Col. McKay in Calcutta, Col. Donovan in Madras, and Dr. Caleb in Lahore. In later years, with the establishment of whole-time Professorships in the subject, Physiology has entered a new phase, and now we witness a marked increase in the output of original research work from the physiological laboratories in all parts of India.

It is no longer a subject of the medical curriculum only, for now several Universities in the country grant B.Sc. and M.Sc. degrees in Physiology. It is also an encouraging sign, that the subject is taught not merely in Medical Colleges but also in Science Institutes of certain Universities, such as Calcutta. The movement has even spread to the schools, and Physiology is one of the subjects that can be taken for the Matriculation Examination of most Universities in the country.

The best feature of Physiology in India is that the physiological laboratories here are, speaking generally, very well equipped. Hitherto, they have directed their attention more to teaching than to research. In 1928, the late Sir Walter Fletcher, an eminent physiologist of the Cambridge School, who was then Secretary of the Medical Research Council in England, visited the physiological laboratories in Grant Medical College. After very careful inspection, he turned round to me and expressed great pleasure at what he described as '*the latest edition of Foster in India*'. What is true of the laboratories in Grant Medical College is also true of laboratories in other parts of India.

Physiology in Europe.

Speaking of Foster reminds us of the fact that Physiology in its modern sense is a contribution that the West has made to the East. In order to get a correct perspective of its position in India, it is essential to consider its position in Europe and especially in England, with which we are primarily concerned.

In an address delivered in January 1901 on 'Medicine in the Nineteenth Century' before the Johns Hopkins Historical Club at Baltimore Sir William Osler said: 'The study of Physiology and Pathology within the past half-century has done more to emancipate Medicine from the routine and thraldom of authority than all the work of all the physicians from the days of Hippocrates to Jenner, and we are as yet on the threshold'.

What was this remarkable development in Physiology in the latter half of the 19th Century, which brought about such a revolution in Medicine ? The answer to this question takes us back to the middle of the 16th Century.

In the year 1543 Andreas Vesalius, Professor of Physiology at Padua, published his classical and epoch-making book '*Fabrica Humani Corporis*', which once for all abandoned the Galenic tradition which had flourished in Europe for 1,400 years. Hippocrates (460–370 B.C.), the ancient Greek physician, a direct descendent of Aesculapius, is regarded as the greatest physician of antiquity. He believed that health and sickness are due to such factors as seasons, climates, waters and soils, food and exercise, and that the primary seats of disease were the four humours,—blood, phlegm, yellow bile, and black bile. The merit of his work was that he advocated that a knowledge of Anatomy, Physiology, and direct clinical observation of the patient are essential for a knowledge of Medicine. He introduced scientific spirit and ethical ideas into Medicine. Then came Galen (131–201 A.D.), another Greek physician who practised in Rome. He was the greatest Experimental Physiologist before William Harvey. He elaborated a system of Humoral Physiology and Pathology, and suggested that spirits or '*pneuma*' penetrated all parts of the body. He preached that the blood received 'Natural Spirits' in the liver, and 'Vital Spirits' in the left ventricle of the heart, which were converted into 'Animal Spirits' in the brain. He 'proceeded to explain every thing in the light of pure theory, thus substituting a pragmatical system of medical philosophy for the plain notation and interpretation of facts as taught by Hippocrates. The effect of this dogmatism and infallibility upon after-time was appalling'. (Garrison.) During the middle ages neither Physiology nor Medicine made any progress whatsoever. The reason, as Sir Michael Foster says, was that 'the Church held the gates of learning and they who entered were bidden to tread her path and hers alone. Her methods became the methods of all scholars. Under her guidance, the written word took the place of the made world. The pursuit of truth ceased to be the looking into the phenomena of nature and for the seeking for the reason why ; it narrowed itself to asking what the teachers taught. The method which had proved triumphant in the search after things spiritual was taken to be the method in all enquiry and biological enquiry was no exception. As spiritual truths were learned by the study of the revealed word, so anatomical and medical truths were to be sought for, not by looking directly into the body of man, not by observing and thinking over the phenomena of disease, but by studying what had been revealed in the writings of Hippocrates and Galen. As the holy Scriptures were the Bible for all men, so the works of the Greek and Latin writers became the Bible for the anatomist and the

doctor. Truth and science came to mean simply that which was written, and enquiry became mere interpretation.'

In '*Fabrica Humani Corporis*', Physiology and Anatomy are beautifully blended together. It is based on the author's own observations made by dissection of the dead body. In the revival of learning, which took place during the Renaissance, Andreas Vesalius (1514–1564) was the greatest master-mind in European Medicine after Galen. There are other notable names belonging to this period, such as Eustachius (1524–74), Columbus (1516 ?–1559), Fallopius (1523–62); and Fabricius ab-Aquapendente (1537–1619), who was Harvey's teacher at Padua.

The next great event was the advent of William Harvey (1578–1657), who was the greatest name in Medicine in the 17th Century. He is rightly regarded as the founder of Modern Physiology. He was born at Folkestone in Kent and studied at Cambridge and Padua. At the latter place he imbibed the tradition of Andreas Vesalius. He was the discoverer of the circulation of blood which he described in his classical book 'De Motu Cordis'; and his dictum 'Omne vivum ex ovo' based on embryological researches is famous. His true greatness, however, consists in introducing the experimental method in physiological investigations. This was a great contribution, which has had a profound influence on Modern Physiology and Medicine. Prior to this, Physiology was the playground of numerous theories, mostly fantastic and obscure. He pulled it up from the quagmire of dogmas, and gave it a respectable position among the sciences. Since then, it has begun to breathe freely. A little later, after the discovery of the compound Microscope, important microscopic discoveries were made by Loewenbock (1632–1732), Malpighi (1628–1694), and Swammerdamn (1637–1658).

In the 18th Century, we come across another great imposing figure, Albrecht Von Haller (1708–1777), a master-physiologist, who for the first time put together an enormous amount of facts, systemized and harmonized them in his monumental work '*Elementa Physiologiae Corporis Humani*'. He raised Physiology to the status of an independent science. The great discoveries in Chemistry and Physics during this period had a profound influence on Physiology, and men searched for a physico-chemical explanation of vital phenomena. It was at this time, that Electro-Physiology had its origin. Luigi Galvani (1737–1798) of Bologna discovered that electricity is produced by the living animal body, especially by nerves. Alessandro Volta (1745–1827), Professor at Pavia, showed that a muscle can be thrown into tetanic contraction by repeated electric stimulation. The isolation of Oxygen by Joseph Priestley (1733–1804) and of the respiratory interchange of gases in the lungs by Laurent Lavoisier (1743–1794) destroyed the old

Phlogiston theory for all time. Lavoisier also showed, that combustion and respiration are analogous processes, the end products of each being the same.

In the 19th Century Physiology, the greatest figure is Johannes Müller (1801–1858). He was an indefatigable investigator, with a fine critical mind, who brought his profound knowledge of Physics, Chemistry, Anatomy, Zoology, Embryology, and Histology to bear on his physiological investigations. While investigating individual problems, he always kept his eye on the larger problem of life as a whole. The physiological knowledge of his time was incorporated by him in his '*Handbuch der Physiologie des Menschen*', a model text-book of its kind. Like Haller's '*Elementa Physiologiae Corporis Humani*', it is a great classic, full of facts and original ideas. He was in a true sense the founder of Scientific Medicine in Germany, and had amongst his pupils men like Schwann, Henle, Köllicker, Virchow, Du Bois Reymond, Helmholtz, and Brücke.

We find Physiology developing along two main paths during the 19th Century. In the first place, Wöhler, Liebig, Voit, Pflüger, Zuntz, Hoppe-Seyler, Hammersten, Bunge, Halliburton, Baumann, Kossel, and others led its development on the chemical side, so much so that Physiological Chemistry became more and more independent. It has latterly been designated *Biochemistry* and tends to part company with the parent science. Secondly, Carl Ludwig, Helmholtz, Du Bois Reymond, Marey, and others led its development on the physical side. The introduction of the graphic method by Ludwig became the favourite method of investigation by subsequent workers. Animal experiments became more and more common. Operative Physiology bore rich fruits in the hands of the celebrated French physiologists, Magendie and Claude Bernard, and latterly in the hands of the great Russian physiologist, Pavlov.

Physiology in Great Britain.

And now let us direct our attention particularly to Great Britain, which undoubtedly is the fountain-head of Physiology as well as Medicine in India. The founder of Modern Physiology and Medicine in the 17th Century was an Englishman, the great William Harvey. Subsequently Stephen Hales, John Hunter, and William Hewson made important contributions to the science. But in the first half of the 19th Century England was far behind Germany and France in this respect. There was no one there at the time who could rank with Johannes Müller, Carl Ludwig or Claude Bernard. The reason was that no one took up Pure Physiology there as a vocation. The state of affairs there is described admirably by Sir Edward Sharpey-Schafer in his 'History of the Physiological Society'. Any surgeon or physician was considered competent to teach the

subject in the Medical Schools. Schafer says that in one place only—University College, London—was a lamp kept burning; the lamp was that of William Sharpey, who was appointed Professor of General Anatomy and Physiology there in 1836. Although he himself made no great discoveries in Physiology, British Physiology owes a deep debt of gratitude to William Sharpey (1820–1880), in that he inspired the love of the science in those who worked with him, encouraged others to undertake research work, and founded the Modern School of Physiology in England, of which England now is so justly proud. The developments at University College were of the utmost importance. Let us follow them.

Michael Foster, an old student of University College, was persuaded by Sharpey to give up his medical practice at Huntingdon and come to University College to teach Physiology with the title of Professor of Practical Physiology. According to Schafer, this appointment of Michael Foster proved a decisive factor in the history of Physiology in Great Britain.

Now, at Cambridge fortunately at the time there was a far-sighted Professor, who was anxious to improve medical education there. This was Professor George Murray Humphry, Professor of Anatomy in the University. He was very keen for the establishment of a Chair of Physiology there. As a preliminary step he persuaded the authorities of Trinity College, Cambridge, to establish a Praelectorship in the subject in the College. Michael Foster, then at University College, was invited to occupy the position. He did so in 1870, and at once set seriously to work; and attracted a number of able and keen young men around him. He became Professor of Physiology in the University in 1883. He was a great teacher. Amongst his pupils were men like Francis Maitland Balfour, Milnes Marshall, Sidgwick, Ray, Francis Darwin, Vines, Walter Gaskell, John Newport Langley, Charles Scott Sherrington, Joseph Barcroft, Henry Head, Charles Scott Roy, John George Adami, and George Romanes. It may be of interest to note that Sir Charles Sherrington carried the tradition of the Cambridge School successively to St. Thomas's Hospital, London, to Liverpool, and finally to Oxford.

Foster retired in 1903. He was succeeded by Langley. On Langley's death in 1925, Joseph Barcroft was appointed Professor of Physiology at Cambridge. He by the grace of God is still occupying Foster's Chair there. Foster, Langley, and Barcroft, the leaders of the Cambridge School, have influenced the development of Physiology not only in Great Britain but in all parts of the world.

At University College, London, Burdon Sanderson succeeded Michael Foster, when the latter went to Cambridge. Subsequently he succeeded Sharpey as Professor, when the latter retired in 1870. Edward Sharpey-Schafer was appointed

Assistant to Burdon Sanderson in 1874, and subsequently became Professor in 1884, when Burdon Sanderson went to Oxford as Wayflete Professor of Physiology. In 1899 Schafer went to Edinburgh, and in his place Ernest Starling became Professor at University College. He was succeeded by Archibald Vivian Hill, who, when appointed Foulerton Professor of the Royal Society, was succeeded by Lovatt Evans, who I am happy to say now occupies Sharpey's Chair at University College.

At Oxford, Burdon Sanderson was succeeded by Francis Gotch, and he in turn by Sir Charles Sherrington. On Sherrington's retirement recently John Mellanby has gone from St. Thomas's Hospital to Oxford as Wayflete Professor.

University College, London, Cambridge, Oxford, and Edinburgh have been the nuclei of British Physiology during the last 50 years. They have been responsible for the development of Physiology in Great Britain, and the British Empire generally, not to speak of other countries. Their influence has spread to India also. In recent years, the subject has received a great impetus. More and more workers are being attracted towards it.

Such was the development of Physiology in Europe and especially in Great Britain; and such was its position in India.

Physiology in India: The Future.

My object in addressing you to-day, however, is mainly to direct your attention to the future of Physiology in India rather than its past. The purpose of looking back on the past is to seek guidance as to the lines of future effort. It should make us redouble our efforts. Physiology has a brilliant future in this country. There are many problems in the solution of which the guidance and help of the physiologist are indispensable. The fields for research work in Pure and Applied Physiology in India are vast. There is urgent need for more workers.

Permit me to mention some of the problems in Physiology, which we in India can profitably take up for investigation.

(*a*) *Physiology and Social Service.*

I have always held the view that a knowledge of Physiology is of immense value in dealing with many social problems. The value of physiological research to the 'labouring' life is inestimable. Sir Leonard Hill and the late Professor J. S. Haldane have played a great part in applying the discoveries of the laboratories to the problems of the workshop and the mines.

The physiologist was formerly regarded as rather an unpractical theorist who was more interested in the twitchings of frog's muscles than in the affairs of men and women in this world. But this is not so to-day. We have now realized that

Laboratory Physiology is not an end in itself, but a means by which we can understand the larger problems of life, and especially human life on this earth.

A great believer in the rôle of Physiology in the welfare of a nation was the late Sir Walter Fletcher, by whose premature death in 1932 British Physiology suffered a great loss. In a national broadcast address, he once said 'We can find safety and progress only in proportion as we bring into our methods of statecraft the guidance of biological truth'. This is perfectly true.

It is rather a melancholy fact, that in proportion to the knowledge of Physics and Chemistry, the knowledge of biological sciences in the country is comparatively meagre. And yet in considering ways and means to bring about social reconstruction and physical well-being of the people, a knowledge of Physiology is indispensable.

In matters such as factory and mine legislation in the interest of the health of the workers, pure food laws, maternity and child welfare work, antenatal and postnatal care, marriage laws, physical fitness, and knowledge of personal hygiene especially in regard to rest, exercise, hours of work, diet, etc., who can deny that a knowledge of Physiology is not a *sine qua non* ?

(*b*) *Nutrition.*

The subject of Nutrition is engaging much attention in India to-day. And quite rightly so. I hope I am not exaggerating when I say, that easily quite one-half of Physiology comprises the topic of bodily nutrition. It is undoubtedly the special domain of the physiologist, and it is he who has made the largest contributions to our knowledge of the subject.

With the birth of Chemistry in the 17th Century and introduction of the experimental method, *Nutrition* began to assume the shape of a real science. Liebig was the founder of modern Nutritional Physiology. He and his pupil Voit, and Rubner (who was Voit's pupil) established the laws of quantitative metabolism. They made it an exact Science. Rubner demonstrated the important principle of conservation of energy which holds good in Mammalian Physiology. With the aid of the Respiration Calorimeter, Atwater, Benedict, Magnus-Levy, and Lusk worked out the detailed application of the principles already established.

With the increase in the knowledge of Chemistry and Physiology, we have learnt a great deal more about food and its use in health and disease.

During the last 25 years or so, very important investigations have been carried out in the domain of the qualitative side of dietetics, especially the biological value of different proteins of animal and vegetable origin, and of the special significance of

the mineral constituents of the diet. To Sir F. G. Hopkins, Professor of Biochemistry at Cambridge, belongs the credit for the discovery of *Vitamins*, which play such an important part in Nutrition. Our knowledge of these so-called ' accessary food factors ' is increasing rapidly.

In opening a discussion in the section of nutrition at the Annual Meeting of the British Medical Association at Oxford in 1936, Major-General Sir Robert McCarrison, C.I.E., M.D., I.M.S. (Retd.), who did important research work on nutrition in India, discussed the *contacts*, which the newer knowledge of nutrition has established. He quite rightly said that these contacts were with Medicine, Bacteriology, Pathology, Obstetrics, Gynæcology, Surgery, Anatomy, Physiology, Biochemistry, Psychological Medicine, Neurology, Orthopædics, Radiology, Oto-rhino-laryngology, Tuberculosis, Dermatology, Therapeutics, and History of Medicine. In the opening paragraph he said that he hoped that on future occasions, the work of this section would not be limited to physiological, biochemical, pathological, and medical aspects of the subject, but that it will include those that are veterinary and agricultural.

I am very happy to say, that the contact of nutrition with the veterinary and agricultural sciences that he desired is being established in India at this Session of the Indian Science Congress by a joint Session of these two sections.

The subject of *Nutrition* in India needs to be investigated from many points of view. To the physiologist it offers great opportunities for original research work. I trust many workers would be attracted by it, for the knowledge that is gained will be of immense benefit to our countrymen.

(c) *Racial and Anthropological Physiology.*

It is interesting to note that there is a tendency amongst workers in India to investigate normal physiological constants here. Data have been obtained in regard to the various constituents of the Blood, Blood-pressure, Vital Capacity of the Lungs, Basal Metabolic Rate, etc. This information is of the utmost value. Thus :—

(i) It would indicate if the normal data obtained here differ in any way from those obtained from inhabitants in European countries.

(ii) It would throw light on any racial or environmental variations that may occur. We shall thus have a basis for Racial and Anthropological Physiology, which really is a very important branch of Human Physiology, and has not received sufficient attention hitherto.

(iii) These figures would also help the practising physician, as they will furnish him with the necessary

information in regard to the deviations from normal that occur in different diseases in the case of inhabitants of this country.

(*d*) *Adaptation to Tropical Climate.*

Another fruitful line of physiological investigation is to ascertain the factors concerned in the adaptation of the human being to tropical conditions. A certain amount of work on the subject has been done in recent years, but the whole mechanism is not yet clearly understood. Undoubtedly here as elsewhere the famous dictum of Claude Bernard 'La fixite du Milieu interieur est la condition de la vie libre' so ably discussed by Sir Joseph Barcroft in his well-known book 'Features in the Architecture of Physiological Function' holds good. It would be of great interest to collect more data, regarding the reactions of the human body to variations of atmospheric temperature and humidity, to correlate them, and to arrive at a comprehensive explanation of them.

It will be seen, I trust, that the effects that are observed result from the cumulative action of a number of factors, each of which alters in a lesser degree, and like any other adaptation, the adaptation to the tropical climate is an 'integration' (Barcroft).

I have jotted down at random some of the problems that can be taken up by us for investigation. But in research work, the important thing is to be guided by one's own inclinations. The essential thing is to acquire love for the science, to study it for its own sake, and to make investigations with the object of discovering scientific truth, without necessarily any idea of the *applications* of these discoveries.

Physiology in the Medical Curriculum.

My remarks here would be very incomplete if I did not make a reference to the position of Physiology in the medical curriculum. In the preclinical group of subjects Physiology occupies a position of the first rank. And rightly so, for unless one knows the normal functions of the body, how is one to understand the deranged function associated with disease? There has been a great deal of discussion in recent years in England and elsewhere regarding the scope and function of this preclinical instruction. The complaint is that too much stress is laid on 'Pure' Physiology, and not enough on 'facts' which are of clinical importance, that the student is required to possess knowledge of vast amount of 'details', which are of no use to him in the clinical work afterwards, and that the outlook of the student when he enters the wards is not sufficiently orientated towards the clinical work he is about to begin. The teachers of the preclinical subjects retort that their business is to impart

a scientific and not a vocational training. For a superstructure of Applied Science a solid foundation of Pure Science is necessary, and that it is futile to talk of 'applications' of Physiology to the first and second year students, who are completely out of touch with hospital work. In my opinion these two opposite points of view can be reconciled. The wide gulf that separates the preclinical and clinical sciences should be bridged, and there should be continuity of instruction in preclinical sciences in the clinical years.

May I invite your attention to the Report published in 1935 of the Conference of the Representatives of the Universities of Oxford, Cambridge and London, Royal College of Physicians of London, Royal College of Surgeons of England, and the Society of Apothecaries of London on the Medical Curriculum, whose Chairman was Lord Dawson of Penn. The revision of physiological teaching and its correlation with the clinical part of the curriculum are admirably discussed here. But to my mind, the most important thing is to show patients to the students while receiving instruction in Physiology, in order to demonstrate the derangement of function that has occurred. 'While it is essential,' says the Report, 'that the student should become acquainted with laboratory methods of scientific research, should himself make experimental observations and should be trained to carry out accurate determinations as well as careful dissections, the relevancy of these requirements to his subsequent study of the living human body should not be allowed to escape his notice. The normal function of an organ can be described and observed in the course of physiological teaching, but it would form more permanent associations in the student's mind if variations from the normal could, at the same time, be demonstrated in the living human subject. Knowledge of the normal activities of the circulatory system observed in an animal or in normal man is amplified in a valuable way when compared with the results of a defect of the circulatory mechanism in man; the comparison not only reinforces memory and stimulates criticism but excites attention and interest. The demonstration of a hemiplegic patient will teach a student many facts about the physiology and anatomy of the pyramidal tract which cannot be learned in any other way.'

I trust, the Universities in India will appreciate the truth of this and will revise their curriculum accordingly.

We are all very glad that the Royal College of Surgeons of England has arranged to hold the Primary F.R.C.S. Examination in India. It was held for the first time in Madras in 1935, in Calcutta in 1936, and will be held in Bombay in 1938. This has already given a great impetus to the study of Physiology in all the Medical Colleges. Passing the Primary F.R.C.S. Examination in India is a great help to those who aspire to get the Fellowship of the Royal College of Surgeons of England.

We are very thankful to the authorities of the Royal College of Surgeons for this. And we are specially grateful to Major-General Sir Cuthbert A. Sprawson, Director-General, Indian Medical Service, through whose efforts the proposal achieved practical shape.

Concluding Remarks.

I have briefly placed before you some aspects of *Physiology in India.* It came to India in the thirties of the last century with the introduction of Modern Medicine. You will observe that it was planted on this Eastern Soil at a time when it was not in a very flourishing state in Great Britain. It has made slow but steady progress and we can all look to the future with hope and confidence.

Considering the great advances in Physiology during the last 4 or 5 decades, Osler's remarks, which I have already referred to, namely that 'the study of Physiology and Pathology within the past half-century has done more to emancipate Medicine from the routine and thraldom of authority than all the work of all the physicians from the days of Hippocrates to Jenner and we are as yet on the threshold' is as true to-day as it was in January 1901 when it was first made. In order to escape from empiricism and legitimately to claim the status and dignity of a science, Medicine must have Physiology as its *basis.* In order that Physiology and Medicine may serve each other, it is as much imperative for physiologists to teach and investigate Physiology, as for the physicians to apply it to Medicine. But Physiology has other aims of its own. Some of the greatest discoveries in Physiology in recent years have been made by men who had no medical training whatsoever. It has flourished most in those Universities where it has led an independent existence like Physics and Chemistry. Although the ultimate aim of all sciences is the welfare of mankind,—and this is perhaps true more of Physiology than of any other science—the immediate aim of any scientific endeavour must be the discovery of *truth,* irrespective of its possible applications.

This common aim brings all the scientific workers together breaking down all barriers of race, nationality or creed. Thus it is one great potent instrument for the promotion of international goodwill, friendship, and peace in the world.

Permit me to convey to you some messages of greeting and encouragement I have received from our colleagues abroad. Professor A. V. Hill, F.R.S., says :—

'If Science had no other purpose at all, no other result, it would probably be worth while for ordinary people to encourage it because of this international quality. Collaboration between different groups, different countries, and different races seems to be far easier in scientific matters than in any others : perhaps

because there is a court of appeal, viz. nature, which will settle disputes by experiment, and opinion and emotion are not the only guides. I am often astonished when I realize how far my only circle of friends and collaborators is international. It never occurs to one that they are of a different race or nation. They are just citizens of the Scientific Community.

India is well on the way. In some subjects, particularly in Physics and Mathematics, Indians are already collaborating very effectively with the rest of the world. Indian scientists are beginning to be known, in person and by their work, in all the countries of the world. You must see that this becomes true also of Physiology. How to do it I cannot tell you—I do not know your conditions well enough. Somehow you must make Physiology "Intellectually respectable", so that men of really first-class ability will be attracted to it. At Cambridge, as you know, Physiology is just as "respectable" as Physics: it is certainly just as difficult as Physics. Claim for it an independent and honourable place, such as Physics has: do not let it be just a handmaiden (as the old saying was) of Medicine. Physics is not the handmaiden of Engineering. If it had been, Engineering would be in a bad way, for modern Engineering depends upon physical knowledge and Physics would have made no progress if it had been the handmaiden of any other Science or Art. Independence and an honourable position are required, and if you can help to give Physiology in India these, you will get first-class youngsters in to join it. A danger is that no man may be allowed to hold any place of importance in Physiology unless he has a medical degree. Avoid this tradition like poison. It means that you will miss many of the ablest people of all—your Pasteurs, Langleys, Barcrofts, Cannons, Baylisses, Howells, Bronks, Lucases, Mineses, Kroughs, Lapicques. We shall look forward in England to seeing your able young men working with us: be sure that they *are* able before you send them, or they will waste their time and ours. Lim, the Chinese physiologist, asked me if I would have a pupil of his to work with me. I said "Yes, if you can send me a really good one. It's a waste of time otherwise". He sent me his best, T. P. Feng, who is so good that I put him as high as anyone I have ever had (and that is pretty good). It is quality, not quantity or numbers, which counts in Physiology. All men are not equal—one Rutherford is worth 100 ordinary physicists, one Pavlov produced more effect than 10,000,000 ordinary Russians in winning respect for his country. So guard and watch for and nurse the able youngster, and make things easy for him, and let him have as much independence as he can bear: and then send him out to see how things are done here or elsewhere. He will make friends, he will win respect for his ability, he will aid in establishing in India also that international brotherhood which is superior to race, religion, politics, disturbances, even to scientific

differences of opinion—the international brotherhood of scientific people.'

Professor E. D. Adrian, F.R.S. (Cambridge), sends a message of most cordial goodwill and says: 'It is a great pleasure to think of the great scientific activity in India to-day and of the reunion of scientists which is foreshadowed by the announcement of the Congress. It would have been a still greater pleasure to me to have been present at its deliberations, but at least I may do myself the honour of wishing you all every success in your joint endeavours in the cause of scientific truth and of the welfare of Mankind'.

Greetings have also been received from Professor Sir Joseph Barcroft (Cambridge), Professor E. B. Verney (Cambridge), Professor W. H. Howell (Baltimore), Professor C. H. Best (Toronto), Professor I. de Burgh Daly (Edinburgh), and Professor C. Lovalt Evans (London).

We are all most grateful to our distinguished colleagues abroad for their good wishes and co-operation which will undoubtedly go a long way to help us to take to our task with redoubled zeal and effort.

The two greatest needs of the hour in the scientific world in India are :—

(*a*) To have more scientific workers of first-class ability.
(*b*) To have amongst the scientific workers harmony and goodwill.

Let me take you back for a moment again to William Harvey, about whom I have already spoken. In conveying his patrimonial estate of Burmarsh by means of an indenture to the Royal College of Physicians of London, he gives the following advice :—

> 'To search and study out the secrets of nature by way of experiment; and also for the honour of the profession to continue in mutual love and affection among themselves ever remembering that *concordia res parvae crescunt discordia magnae dilabuntur.*'

I address these words not only to the Section of Physiology here but to all the scientific bodies in the country. Let us all follow Harvey's advice and live and work together like brothers in mutual harmony, peace, and goodwill in the interests of science.

Gatherings such as this, apart from promoting scientific discussions and advancement of science bring about unity and friendship amongst the workers. They establish such contacts, as are not possible in any other way. This Section, I hope, will promote solidarity and cordial relations amongst all the physiologists in India. Thus, Physiology will make a great headway, and its progress will be a source of pride to us all.

Let us therefore march forward and fulfil our mission of serving Physiology with faith, hope, and charity,—with faith

in the ultimate benign aim of our science; with hope, which will strengthen all our efforts; and with charity, in which as men of science to be worthy of our vocation, we must live, move, and have our being.

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SECTION OF PHYSIOLOGY

Abstracts

1. A preliminary note on the relation between the acetyl-choline content of the brain and the choline esterase concentration of the serum.

B. B. Dikshit, Bombay.

The author has demonstrated the presence of acetyl-choline (A.C.) in the brain and his work has been confirmed by others. The A.C. concentration in the brain varies widely in different species of animals. These concentrations were studied in various animals and it was found that the order varied from highest to lowest as follows :—Horse>Dog>Guinea-pig>Cat>Rabbit>Rat. Thus the horse showed the highest concentration of A.C. in its brain per grm. of tissue and the rat the least. It was found that this order was exactly the same as that found by Stedman and his associates for the 'choline-esterase' concentration of the serum. Stedman and his co-workers have demonstrated an enzyme in the blood which has a specific action of destroying esters of choline and which they have named 'choline-esterase'. The choline esterase concentration varies in the blood of different species of animals and for the species mentioned above it varies from highest to lowest as follows :—Horse>Dog>Guinea-pig>Cat>Rabbit>Rat.

It will thus be seen that the A.C. content of the brain varies directly as the choline esterase concentration of the serum. Stedman's work was repeated in the case of dogs, cats and guinea-pigs and confirmed. The possible conclusion that one may draw from these experiments is that if the enzyme concentration in the blood of a given species of animal is high its A.C. content of the brain should also be high and *vice versa*.

2. Influence of histamine and acetyl-choline on intestinal movements.

B. T. Krishnan, Madras.

All parts of the small intestine were found to be equally well stimulated by histamine and acetyl-choline and atropine inhibited the stimulating effect in both the intact and isolated bowel. These results do not bear out the finding of Mackey that the histamine effect is most marked in the ileum, that of Bernheim that acetyl-choline acts only on the lower intestine in cat and the findings of Dale and Mackey that atropine does not inhibit the stimulating action of histamine on excised segments. Histamine is found to have its maximum stimulating effect when the tone of the muscle is low and acts both directly on the muscle and also on the para-sympathetic nerve-endings, causing thereby liberation of acetyl-choline which has a further stimulating effect on the smooth muscle.

Acetyl-choline is found to cause an initial depression or inhibition of the movements before the stimulation is observed. This inhibition appears to be due to the action of acetyl-choline on the medulla of the suprarenal gland and on sympathetic ganglia. So when acetyl-choline is

used therapeutically some delay is to be expected before the stimulating action is obtained.

The reversal effect of acetyl-choline on blood-pressure after atropine was also observed. This effect was little or absent after both atropine and ergotoxin.

3. Observations on the action of Ergotamine.

B. Narayana *and* H. N. Banerji, Patna.

The action of Ergotamine was studied on the isolated œsophagus, small intestine, rectum and bladder of the frog. The isolated tissue was suspended in a bath containing Ringer through which air or oxygen was bubbled and movements recorded by a lightly balanced lever. Ergotamine caused an increase in the amplitude of contractions of the œsophagus. Its action on the small intestine was uncertain and its action on the rectum was to cause an increase in the tone and movements although in some preparation a diminution in tone was noticeable. Similar results were obtained with Ergotoxin on the rectum of the frog. Ergotamine also caused an increase in the tone and contractions of the bladder of the frog.

Adrenaline caused a diminution in the tone and contractions of the œsophagus, small intestine, rectum and bladder of the frog following Ergotamine.

It seems that Ergotamine has a stimulant action on the plain muscle of the isolated tissue of the frog as above and it does not seem to abolish the inhibitory action of adrenaline.

4. Influence of Ca, K, curare, cobra-venom and ajmaline group of alkaloids on the fatigue of skeletal muscles of frog.

N. M. Basu *and* R. Ghosh, Calcutta.

The rate of onset of fatigue was determined by recording the contractions of frog's gastrocnemius on a slowly moving drum, the muscle being stimulated at the end of each rotation of a rapidly moving drum by the almost instantaneous make and break of the primary circuit caused by a very short-lived touch of a pointer with the spring contact in the drum. Stimulations of the muscle by a metronome give rise to unequal contractions, break shocks being stronger than the make shocks. If the tetanus spring is used for stimulations and if the Helmholtz's principle be applied for the equalization of make and break shocks, uniform and good curves of fatigue are obtained, but fatigue sets in very quickly. Accordingly changes in the fatigue curve, caused by drugs or ions, are not well brought out. In the method adopted in these experiments the break shocks have been eliminated as they fall in the refractory periods of the previous make shocks and the fatigue sets in gradually, so that any change in the features of the curve is clearly shown.

The effects of Ringer's solution on fatigue were contrasted with the effects of Ringer's solution containing $1\frac{1}{4}$, $1\frac{1}{2}$, 2, 3 and 4 times the normal amount of Ca, also with Ca-free Ringer and further with Ringer's solutions containing $1\frac{1}{4}$, $1\frac{1}{2}$, 2, $2\frac{1}{2}$ and 3 times the normal amount of K. The results obtained appear to be puzzling. With an increase in Ca concentration up to 2 times, the contractions of the muscle are more powerful, the contraction-remainder is less than in Ringer and fatigue is delayed. With higher concentrations of Ca, contractions become less powerful and the onset of fatigue is quickened.

In Ca-free Ringer, contractions are less powerful and the contraction-remainder very slight, but the effect on the onset of fatigue is doubtful.

In K, contractions are more powerful, contraction-remainder very slight and the fatigue is definitely delayed. The effects of very high concentrations of K are similar to those of Ca.

The effects of fatigue in Ca-free Ringer were compared with those in Ca-free Ringer containing Curare and Cobra-Venom.

The effects of Curare on fatigue are not very pronounced. With sufficient concentration there is some stimulation of muscle and the fatigue is accordingly somewhat delayed.

The effects of Cobra-Venom are definite and well-marked. With an increase in concentration there is considerable stimulation of the muscle and the fatigue is markedly delayed.

The effects of Ajmaline group of alkaloids in Ringer's solution were also noted. There is definite augmentation of muscular contractions and the fatigue is much delayed.

5. Blood pressure, carbon-dioxide and suprarenal glands.

S. N. Mathur, Lucknow.

It is shown that suprarenal glands exert some tonic action on the peripheral vessels, as for some time after their extirpation if carbon-dioxide be given it exerts a better dialator action. This, however, soon passes off, probably, on account of other mechanisms, e.g., accessory suprarenals, liver and sympathin which come into play in the absence of these glands.

6. Oxygen consumption and adrenaline.

S. N. Mathur, Lucknow.

If minute quantities of adrenalin are administered to anæsthatized animals there is an appreciable increase in their oxygen consumption. If, however, it is given in quantities as are usually given to register a large increase in blood pressures, oxygen consumption definitely decreases.

7. Effect of hyperthyroidism on the metabolism of vitamin C.

S. N. Ray, Calcutta.

The amount of vitamin C required by guinea-pigs for complete protection is greater in the case of animals fed on dessicated thyroid. In rats, thyroid feeding has no effect on the concentration of ascorbic acid in liver or suprarenals but the concentration of the acid in kidney is greatly diminished. This diminution is roughly proportional to the amount of thyroid ingested by the animals.

8. Vitamin C content of some fruits available in Calcutta during the rainy season and some common articles of food which are eaten raw.

N. M. Basu *and* P. Das, Calcutta.

The vitamin C content of a number of fruits and some articles of food which are eaten raw has been ascertained by the method of Harris and Ray as modified by Ghosh and Guha. It is interesting to find that the juice of Tulsi leaves, green 'Lanka' and small 'Mula' contains a fairly large amount of vitamin C. The relationship between the chemical reaction and the ascorbic acid content of these foods is discussed.

9. Estimation of total (combined and free) vitamin C in some food-stuffs.

P. N. SEN GUPTA *and* B. C. GUHA, Calcutta.

A process has been developed by which the total vitamin C content (including free and bound vitamin C) in several vegetable food-stuffs has been determined It is shown that the ordinary process of extracting vitamin C has given wrong values of the vitamin C content of natural food-materials.

10. The ascorbigen content of plant and animal tissues.

J. C. PAL *and* B. C. GUHA, Calcutta.

A study of the ascorbigen content of a number of vegetable food-products and of animal tissues has been made. In general, it appears that leafy vegetables contain considerable quantities of ascorbigen, while acid fruits contain practically nil. Animal tissues so far studied also appear to be free from ascorbigen.

11. The estimation of ascorbic acid in urine.

R. K. CHAKRABARTY *and* B. C. GUHA, Calcutta.

By applying different methods to the estimation of ascorbic acid in urine, it has been found that treatment with mercuric acetate by van Eekelen's procedure removes part of the ascorbic acid. Treatment with formaldehyde seems to be the best, as it does not interfere with the titration and at the same time it checks the interference by cysteine and thiosulphate even if they are added to the urine. No interference by the presence of uric acid has been observed.

12. A nutritional study of some cooked Bengali dietaries.

J. C. PAL *and* B. C. GUHA, Calcutta.

Although investigations have been made on the nutritional index of people in different parts of this country and the nutritive values of individual food-stuffs are under study, hardly any investigation has so far been carried out on the nutritive values of cooked diets, as they are actually consumed. The nutritional values of diets actually consumed in some students' hostels and middle class families in Calcutta have, therefore, been studied. The averages for protein and calcium work out to be lower than Stiebeling's standard values but higher in the case of iron. Deficiency is, therefore, indicated mainly in respect of calcium and protein, specially of protein of animal origin.

13. Iron and copper content of the blood of normal Bengali subjects.

S. N. RAY *and* R. GANGULY, Calcutta.

The average Bengali dietary contains about 11 mg. of food-iron per man per day. This allowance is about 25 to 30% lower than the minimum set by Sherman. A similar difference in the iron and copper contents of blood is also observed when Bengali figures are compared with those of the Europeans. The average values of iron and copper contents of the blood of Bengalis are 39·0 mg. of iron and 0·14 mg. of copper per 100 cc.. whereas the corresponding values for Europeans and Americans are 52·6 mg. and 0·18 mg.

14. Absorption and excretion of tin in rats fed with food prepared in tinned brass vessels.

N. C. Datta, Bombay.

Tinned brass vessels are extensively used in South India for the preparation and storage of various acid food-stuffs. Experiments were carried to study the growth of the animals and also to follow the path and the rate of excretion of tin in the fæces and urine of rats fed with food prepared in tinned brass vessels. The results indicate

(1) The growth of animals fed with food prepared in tinned brass vessels were about 10–15% lower than control animals during a period of 3 to 4 months. The animals however appeared healthy in other respects and no serious poisoning effect was observed in any case.
(2) About 80 to 90% of ingested tin was found in the fæces during the period of feeding. A part of it was however retained in the body for some time which was slowly excreted. Most of the tin retained was found in the intestine and colon. The quantity in the urine was very small showing poor absorbtion of the metal.
(3) Accumulation of tin in the liver was very small. The concentration of the metal in the kidney was much higher than in the liver. It is possible that during the course of its excretion in the urine it was stored in the kidney.
(4) Histological examination of liver and kidney did not show any injury to the Cell structure.

15. Metabolism of amino-acids in heart and in lungs tissues.

K. P. Basu *and* M. N. Basak, Dacca.

Of the different amino-acids investigated viz. l-cystine l-proline, *d*-l serine, *d*-arginine, l-histidine, l-tryptophane, *d*-glutamic acid, *d*-l-methionine, *d*-l-alanine, glycine, glycyl-glycine, *d*-l-phenyl-alanine and l-leucine, only l-cystine and l-proline were found to undergo oxidative deamination in heart and in lungs tissues of rats. The oxygen absorption was measured by Barcroft-Warburg respirometers and ammonia was estimated by the method of Parnas. The deamination of l-cystin both in heart and lungs tissues is not affected by KCN or octyl alcohol. The oxidative deamination of l-proline is completely inhibited by KCN and partially by octyl alcohol.

16. Lead-content of urine and fæces.

K. N. Bagchi *and* H. D. Ganguli, Calcutta.

The determination of the amount of lead in normal urine and faeces with a view to find out its normal limit for the Indians is of immense importance in clinical toxicology. The problem of administration of workmen's compensation act specially in connection with the employees of the printing presses is an important one. Cases with vague and indefinite signs of plumbism which are likely to be diagnosed as such and recommended for compensations may be proved normal by examination of urine and fæces. It is therefore imperative to establish a normal limit for the lead-content of urine, fæces, blood, etc. by examining a large number of healthy people of all castes and creeds. It is obviously fallacious to compare with normal limits of the Europeans in giving an opinion on an Indian.

Lately very good methods have been worked out for determining the quantity of lead in biological materials. In this investigation the colorimetric method of Lynch, Stater and Osler (Analyst, 1934) has been adopted

after slight modification for preventing the formation of a yellow colour. Examination of fæces has been found more useful than that of urine. If the kidney is diseased the elimination of lead is very much restricted and any opinion based on urine alone is not correct. The amount found in fæces is always very much higher than that in urine and is fairly steady.

The following table shows the lead-content of urine and fæces of healthy as well as suspected lead-poisoning cases (employees in the Government Press) :—

	URINE. mgms. per litre.	FÆCES. mgms. per kilo.
In health—		
Indians (Hindus and Moslems) ..	0·002–0·026	0·04–0·13
Anglo-Indians	0·024–0·04	0·13–0·16
Suspected cases of lead poisoning—		
Indians (Hindus and Moslems) ..	0·03–0·38	0·71–4·46
Anglo-Indians	0·38–0·53	2·85–4·50

17. Arsenic in normal human tissues and excreta.

K. N. BAGCHI *and* H. D. GANGULI, Calcutta.

Arsenic is an important poison both for homicidal and suicidal purposes. As it is widely distributed in nature, an exact information about the amount of arsenic normally present in human tissues, excreta and food-stuffs is of great importance in medicolegal investigations. When it is present in large quantity in the viscera of a suspected case of arsenic poisoning, no difficulty arises in giving a definite opinion, but if only a trace of it is detected the question of the normal arsenic-content of the tissues comes in. No systematic study on this line appears to have been made in this country and the findings of the European workers in Europe are often taken into consideration in giving opinion on such cases. The arsenic-content of some of the common Indian food-stuffs has lately been worked out (Bagchi and Bose—*Ind. Sc. Cong. Proceed.*, 1935).

A case is on record in which a pharmacist (in France) was convicted for poisoning his wife with arsenic because a certain amount of arsenic was found in her viscera. It transpired in course of time that the amount of arsenic which was detected in her body was too small and did not exceed the amount which may occur normally and the innocent man was released after eleven years. This case should be an eye opener to all toxicologists and medicolegal chemists in India. An investigation on this line has been taken up and this paper forms only a preliminary note (further work is in progress). The following is the result of analysis of about 25 cases done so far :—

	mgms. per kilo.	
Liver	1·6–2·0	(an infant of 4 months, 0·1)
Kidney	0·6–0·8	(Do. *nil.*)
Stomach	trace–0·4	(Do. *nil.*)
Intestine	0·3–0·5	
Muscles	trace–0·1	
Urine	trace–0·06	
Fæces	0·2–0·4	

18. The influence of humidity on basal metabolism.

S. A. Rahman, Hyderabad (Deccan).

Basal metabolism tests were made on seven medical students at Hyderabad-Deccan in the month of April when the weather is hot and dry. The average basal metabolism was 5·6 per cent. below Harris-Benedict and 6·3 per cent. below Aub-DuBois standards. Tests were made on the same subjects in August when the air was almost saturated with moisture but the weather was not so hot, being on the average 6°C. lower than in April. Three of the seven subjects could not be available in August and the tests were made on only four. Their average basal metabolism in August was 5·4 per cent. below Harris-Benedict and 6·4 per cent. below Aub-DuBois standards. It is therefore suggested that climate which is humid but not hot does not lower metabolism. Further work is proceeding on these lines.

19. A note on reaction to heat.

W. Burridge, Lucknow.

In the course of regular weighings of students at Lucknow it was observed that, as the hot weather came on, gains in weight were noted, whereas when cold set in, losses were noted. Changes due to different clothes would have gone in the reverse order. Hence some bodily change was responsible.

In December heavy clothes are desirable in Lucknow and silks in Bombay. On a journey being taken to Bombay in December, the body weight was observed to be increased in Bombay, the increase being so much as four pounds. This increased weight persisted up to the return to Lucknow. It was suddenly lost on the second day after return. The loss was accompanied by a diuresis which could not be accounted for in terms of fluid intake.

The inference from these facts is that a storage of water within the body is part of the body's adaptation for a high external temperature.

20. Heat and failure of centres from above downwards.

S. N. Mathur, Lucknow.

This paper deals with the observations made post-mortem on Cats exposed to excessive heat. They all died of failure of respiration. As soon as the respiration had failed the chest was opened. Heart was always found beating though the beats were ineffectual to maintain any blood pressure. If in such cases heart could be revived, say by artificial respiration, one single effectual beat was enough to shoot up the blood pressure. This indicates that the vasomotor centre was still working and in fact was maintaining a constrictor tone. The shooting up of blood pressure became impossible after the destruction of the medulla and the spinal cord.

21. Further studies on the crenation of erythrocytes and an explanation of the phenomenon.

N. M. Basu, Calcutta.

Changes in size and shape of r.b.c. in solutions of NaCl of varying concentrations were observed and it was noted that these cells undergo crenations in isotonic, hypotonic and in hypertonic solutions. It was further observed that these cells at first shrink in hypertonic solutions but if they are kept for a long time in the latter, they eventually enlarge. Again, in hypotonic solutions they enlarge at the beginning, but eventually shrink. If the corpuscles are kept in Ringer's solution of which the concentration of NaCl is varied, it was found that the crenations are

either absent or very indistinct and temporary, and the size of the cells undergoes hardly any change. Again if the corpuscles are kept in Ringer's solution but the concentration of $CaCl_2$ is varied, it was found as before that the crenations, if they at all take place, are very short-lived and the cells hæmolyse. The size of the cells is not changed, excepting at very high concentrations of $CaCl_2$ and in these concentrations they enlarge.

All these phenomena can be satisfactorily accounted for, if it is assumed that the envelope of red corpuscles has the structure of an elastic gel the cavities of which are filled up by the micellæ of lecithin and cholesterol. An elastic gel undergoes solvation in contact with NaCl solutions and solidification in contact with $CaCl_2$ solutions. Further, the lipide micellæ become finely dispersed in presence of NaCl solutions but aggregate together and spread out in contact with $CaCl_2$ solutions. When, therefore, the outer gel envelope is solvated and the micellæ are dispersed as in contact with NaCl, flow of water and osmotically active substances in and out of the cells readily takes place causing changes in size. Further, when there is solvation of the gel envelope, there is proportionate loss of elasticity and accordingly when water goes out from these cells, there would be creases, i.e. crenations in their envelope. When water goes in, as the parts in the envelope in between the cavities containing lecithin become more distensible, there is unequal distension of the envelope, giving rise to typical crenations. If the gel envelope is solidified and the micellæ coalesce and spread out in the cavities, there can be neither any flow of water nor osmotically active substances. Accordingly, there would be hardly any change in size or shape of these cells in contact with $CaCl_2$ solutions, excepting such changes as might take place before the above-mentioned effects of $CaCl_2$ on r.b.c. are established. The increase in size of r.b.c. in high concentrations of $CaCl_2$ is due to an adsorption of Ca ions on the surface of the cells, causing an increase in the surface charge and thereby enlargement of the surface membrane. The hæmolysis of r.b.c. in higher concentrations of $CaCl_2$ is due to cracks in the soldified envelope, which are expected to arise when the envelope is either put on the stretch or is made to collapse, especially if the envelope is not completely solidified.

22. Glycolysis in blood.

S. S. Cowlagi, Bombay.

The subject of glycolysis in blood has received the attention of several investigators since 1876. Probably because of the divergent results obtained so far, no definite decision has been reached. It is reported that the glycolysis is due to plasma (C. W. H. Cruickshank and C. W. Startup. *Am. J. Physiol.*, 1932, 99, 408–16) and to corpuscles (C. Lundsgaard and S. A. Holboell. *Compt. Rend. Soc. de. biol.*, 1925, 93, 1680–90). The conflicting opinions may be attributed to the different methods employed for the estimations of lactic acid and to the fact that the blood studied was from different species. An attempt has been made to study the mechanism of glycolysis, and the factors which may influence glycolysis. Therefore only defibrinated horse blood is used throughout this investigation and glycolysis is studied in (1) blood, (2) serum, (3) corpuscles.

1. With regard to blood it is observed that in the early stages the rise in the concentration of lactic acid is rapid while the fall in the concentration of sugar is less marked. Whereas in the later stages the changes are in the reverse order. The sugar does not disappear completely as reported by (J. Eldermann. *Biochem. Z.*, 1912, 40, 314).

2. The glycolysis in serum is less rapid than in blood or even in corpuscles, but the statement of (*I.* Katayama. *J. Lab. Clin. Med.*, 12, 239–54. 1926) that the glycolysis is absent in serum is not confirmed. It is also noticed that there is an appreciable rise in the concentration of

lactic acid, while the sugar concentration does not fall to the same extent. This phenomenon is the same as in the early stages of glycolysis in blood.

3. In corpuscles on the other hand glycolysis is rapid. While there is an increase in the concentration of lactic acid, there is a correspondingly even greater fall in the sugar concentration, as in the later stages of glycolysis in blood. Therefore it is evident that both components—serum and corpuscles are necessary for glycolysis. Investigation of other factors in the mechanism of glycolysis is in progress.

Communicated by Professor P. M. Barve, Wilson College, Bombay.

23. Coagulation time of 'normal' blood.

S. N. MATHUR, Lucknow.

The coagulation of blood is hastened by factors which help in the abstraction of water therefrom and the coagulation time is found to be inversely proportional to the surface of blood placed in contact with water-wettable substances.

24. A method for investigation of the action of drugs on the vascular system of frog.

R. N. ABHYANKAR, Hyderabad (Deccan).

The vessels are perfused with Bayliss' solution. The perfusion pressure is regulated by means of a screw clamp. The pressure tracing is recorded by means of a membrane manometer, while a water manometer indicates the actual pressure at any given moment. The introduction of the screwclamp makes the technique very sensitive to the changes of pressure in the perfusion fluid. The action of drugs may be investigated either by perfusing the vessels with their solutions or by injecting them directly into the rubber tubing connected with the perfusion cannula.

25. A frog vessel preparation and its response to drugs.

B. NARAYANA, Patna.

This preparation involves the perfusion of the blood vessels of the stomach and the gut of the frog.

The abdomen of a pithed frog is opened and the stomach and the gut isolated by cutting the rectal and the oesophageal ends between two ligatures and freeing from the surrounding tissues. The preparation is put on a cork board supported by pins. A very fine cannula is introduced into the Coeliaco-mesenteric artery and tied over it. Perfusion is started and the outflow from the cut veins is allowed to flow down the cork board into a small funnel and drops counted or recorded by a drop recorder.

The preparation can be usefully employed for investigating the action of any drug on the vessels of the frog.

In the above preparation it was noticed that ergotamine and acetyl choline caused vasodilation and Histamine had a slight vasodilator or no effect.

26. Effects of carbon-dioxide on cardiac output.

S. N. MATHUR, Lucknow.

It has been found that administration of Carbon-Dioxide, if the animal is in good condition, definitely increases the output of the heart. Increased output has been noted up to between 20 and 30% of Carbon-Dioxide in a Carbon-Dioxide-air mixture, beyond which a decrease sets in. This increase in output is, to a certain extent, independent of the increased venous pressure.

27. Effects of carbon-dioxide on blood pressure.

S. N. Mathur, Lucknow.

Carbon-Dioxide does not always give rise to increased blood pressure which it is reputed to do; more frequently the pressure falls. This happens even in the presence of other factors tending to raise the blood pressure.

28. Effects of carbon-dioxide on peripheral vessels in intact animals.

S. N. Mathur, Lucknow.

Carbon-Dioxide, which is reputed to dilate isolated vessels does so even in intact animals. This furnishes an explanation why the blood pressure does not rise so often after its administration in spite of the other factors operating in its favour.

29. Effects of asphyxia on circulation.

S. N. Mathur, Lucknow.

It is shown that small degrees of asphyxia of not more than 2 to 3 minutes duration cause an increased output of the heart. This is an important factor which contributes to the increase in blood pressure which this agent is reputed to cause through the stimulation of the vasomotor centre.

30. Asphyxia and extent of response of blood pressure.

S. N. Mathur, Lucknow.

The extent to which the blood pressure rises after giving asphyxia is in direct proportion to the initial blood pressure.

31. The pericardium and its importance.

S. N. Mathur, Lucknow.

It has been observed experimentally that the pericardium puts a check to too excessive a dilatation of the heart. Such a heart as it is unable to maintain its output by further dilatation quickly fails. If at this stage the pericardium be slit open the heart immediately recovers.

32. Action of carbon-dioxide on the heart of ciona intestinalis.

S. N. Mathur, Lucknow.

Small quantities of carbon-dioxide improve the beating of the heart, both in force and rate; while larger quantities depress and ultimately cause its stoppage. Carbon-dioxide was also successfully used to revive 'dead' hearts.

33. Oxygen consumption and sensory stimulation.

S. N. Mathur, Lucknow.

There is an appreciable increase in consumption of oxygen after sensory stimulation, through the sciatic nerve, in anæsthetized animals.

34. Vital capacity of chest in health and disease : intrathoracic pressures.

P. T. PATEL, Bombay.

In the present paper the author describes the relation of vital capacity to intra-alveolar and intrapleural pressures in health as well as in diseases and in therapeutic measures such as artificial pneumothorax, compressed air treatment for asthma.

35. Action of drugs on the pulmonary vessels of the frog.

H. N. BANERJI *and* S. S. MAHMUD SHAH, Patna.

The present investigation was started with a view to find out the nature of the nerve supply to the pulmonary vasculary system of the frog. Perfusion of frog's lungs was carried out with Ringer (Nacl 0·7 g ; Kcl 0·014 g. ; $Cacl_2$ 0·02 g ; $NaHCo_3$ 0·02 g. ;/100 c.c. distilled water) in the anæsthetized frog in which a cannula was tied in the right aorta having ligated all its branches except the right pulmonary artery. A second cannula was tied into the right auricle for the outflow of perfusion fluid. Injections of both adrenaline and acetyl choline into the tube carrying the perfusion fluid brought about vaso constriction. The results go to show that both the sympathetic and the parasympathetic nerves carry vaso constrictor fibres to the lungs of the frog.

36. A method of staining with tannin, orange G and aniline blue.

B. B. SARKAR, Calcutta.

A general method of staining tissues fixed by any of the fixing methods is described in which the sections are first soaked in 10% tannin for 5 minutes followed by 30 seconds in 2% iron alum solution ; after washing they are next mordanted in 5% phosphotungstic acid solution for 10 minutes and stained in a solution containing orange G 2 grams water soluble aniline blue ·5 gram, acetic acid 8 c.c. and distilled water 100 c.c. The sections are then mounted permanently in the usual manner.

37. The intrinsic muscles on the plantar surface of the foot of the Marsupials.

BRIJMOHAN LAL, Hyderabad (Deccan).

Didelphys is an animal the posterior limb of which is least specialized. In this animal there is greatest movement between tibia and fibula. The latter bone articulates with the femur and takes part in the formation of the ankle-joint. Its foot is most primitive having five digits. In this animal, the number of intrinsic muscles is greatest. In parameles, the posterior limb is most rigid and highly specialized. The fibula does not take part in the formation of the ankle-joint and does not move on the tibia. This animal has the least number of intrinsic muscles in the foot. Dasyurus and dendrolagus are between these two extremes as far as the movement between tibia and fibula and the specialization of the posterior limb is concerned. The intrinsic muscles of the foot diminish in the following order : didelphys, dasyurus, dendrolagus, parameles. I find the more specialized the foot becomes and lesser the number of digits, the less are the strata and the number of the intrinsic muscles of the foot.

38. Development of the diaphragm.

H. Ali Khan, Hyderabad (Deccan).

The three layers of cells from which the various parts of the embryo develop comprise the ectoderm, mesoderm and entoderm. A cavity is formed in each lateral part of the mesoderm called the coelom which gives rise to the pericardial, pleural and peritoneal cavities.

A mass of mesoderm called the septum transversum grows in the head region and descends down to the upper lumbar region. The duct of Cuvier passing through the septum transversum forms a ridge over it called the pulmonary ridge which gives rise to the pleuropericardial and the pleuroperitoneal membrane. The development of the heart with the pericardium from the pleuropericardial membrane shuts off the pericardial from the pleural cavity. The liver grows into the septum transversum. The cephalic portion of the septum transversum forms the central part of the Diaphragm, the remaining portion called the ventral mesogastrium forms the coronary and the falciform ligaments. The remaining parts of the diaphragm are developed from the pleuroperitoneal membrane, derivatives of the body wall, the dorsal mesentery and the muscle mass in front of the 5th cervical segment which is innervated by that segmented nerve.

Developmental defects, diaphragmatic hernia is formed by the deficient development of the pleuroperitoneal membrane usually of the left side. Sometimes the pleuropericardial membrane does not develop and the heart and lungs lie in a common cavity.

39. Some observations on the popliteus muscle.

Brijmohan Lal, Hyderabad (Deccan).

The popliteus muscle is inserted into both tibia and fibula, in animals which have movement between these two bones acts as a pronator muscle. In animals in which there is no movement between the tibia and fibula, the muscle shifts its origin to the condyle of the femur and acts as a flexor muscle. Its tendon also acts as the lateral ligament of the knee-joint.

The tendon of M. popliteus indicates by its continuation with the lateral meniscus that it originally gave origin to that ligament.

40. Side lights on the development of Urethra in man.

M. A. H. Siddiqi, Lucknow.

The gross and microscopic anatomy and the embryology of penile Urethra along with the associated glands in Spermophile (Citellus Tridecemlineatus) has been worked out in detail. The Embryological findings throw very suggestive lights on the contribution of ectoderm and endoderm in the development of similar parts in man. The Embryology of urethra in man is being worked out to verify the above hypothesis.

SECTION OF PSYCHOLOGY

President :—K. C. Mukherji, M.A.

Presidential Address

THE SOCIAL MIND OF THE INDIVIDUAL

Ladies and Gentlemen,

It is with great pride and immense pleasure that I find myself here to-day to preside over the deliberations of the psychology section of the Indian Science Congress. I am quite sensible of this distinct honour conferred on me. Psychology has recently made much progress even in India. Its present revolutionary spirit of advance and immense possibilities of progress did not escape the extraordinary insight of the late Sir Ashutosh Mookherjee who first in India separated psychology from philosophy and installed it independently in a well-equipped laboratory of the University of Calcutta. There it has flourished in the midst of its associates—Biology, Physiology, Anthropology, etc., and together with them found a place in the arena of this Congress. It is with one aspect of the development of the psychological science, namely, Social Psychology, that I shall deal in my present address.

It is regretted in some quarters that social psychology has not yet been able to extricate itself completely from general psychology, but to me it seems that the controversy of individual psychology and social psychology will not, however stupendous be the development of the latter, be finally settled because of the intimate alliance between the two. There are writers, however, who lay unequal emphasis on the individual and social aspects of human consciousness and propose to build up a psychology of society apart from an individual psychology and *vice versa*. But we cannot think of a society apart from the individuals nor of the individuals apart from a society. The group and the individual, social life and individual life, are correlatives and neither can be understood singly. So individual psychology and group psychology are by nature inextricably linked up with each other. Individual psychology depends as much upon the psychology of society as the psychology of society depends upon it.

If the all-sufficiency of individual or of social psychology or the reduction of the one to the other is not maintainable, any sharp contrast between them by defining and separating their problems is also untenable. It is true that individual psychology

is concerned with the individual man and his nature, but the individual can scarcely disregard his relations to others. In the individual's mental life someone else is invariably involved. The relations of an individual to his parents and children, to his brothers and sisters, to relations and strangers, to friends and opponents and to the persons he loves and hates, are social relations which help him to co-ordinate and satisfy the manifold impulses of his life. These mental acts fall within the domain of individual psychology which, in dealing with the socially conditioned individuals, takes on the character of social psychology as well in the wide sense of the term. Even Narcissism, though individualistic in its outcome, is socially conditioned and it can hardly be cited as establishing an individual psychology totally distinguished from social psychology. The subject of inquiry for group psychology as for individual psychology is the individual man; but while the former studies a person as influenced by simultaneous relationship to a large number of persons, to none of whom reaction is individual and with whom probably there is no fixed connection or association, the latter limits its quests to the reaction of the individual to another individual or a small group of people with whom he has some sort of fixed relationship. So those social relations which are important for individual psychology are left out in social psychology. But still this does not create any real antithesis between the two. They are both concerned with the individual life which, in order to perfect itself, requires different media of social relations that are complementary to one another. The opposition that seems to exist between the fundamentals of individual and social psychology is artificial and is entirely based on an abstract view of the nature of the individual and of society. Parts cannot be isolated from the whole without being affected themselves or affecting the whole of which they form integral factors. The One exists in and through the Many no doubt, but it is equally true that the Many have no existence independently of the One of which they are factors.

The unity which belongs to a social aggregate cannot be understood by the nature of the units alone, because the units have in fact no existence out of relation to their social grouping. There are not at first individuals and then a social unity, as there might be bricks and then a pile of them. Even the units in their relation to one another do not constitute the essence of social life. For, living in groups is not peculiar to man; it characterizes plants and animals as well. A clump of grasses, a forest of trees, a colony of bacteria or a group of protozoa may show interdependence in respect of the life activities of their separate units; but we do not usually call such groups societies. The relations between their units seem to be purely physical or physiological. Such groups, it is true, show

the first mark or the physical basis of collective existence in that they share a common life; but since they are lacking in conscious relations they cannot be regarded as having a social life. The contact and overlapping of inner selves constitute the most essential element of social life: the social life is an inter-mental life. The substance that pervades the whole society and unites the individual minds in a most living way is essentially mental.

What then is the character of this mental substance? Is it an entity as real as the individual mind or is it a fictitious abstraction—a mere name with no substantial basis? Or is it the concrete organization or phase of the individual minds? The assumption of the existence of collective consciousness finds an analogy in the relation of the consciousnesses of individual cells, of which the organisms of men and animals are composed, to the consciousness of the organism as a whole. The individual cells that ultimately come phylogenetically or ontogenetically from the parent cell or the germ cell cannot be denied some enjoyment of psychical life, however rudimentary. The idea that the collective unity of personal consciousness is greatly dependent upon the functional organization of the cells, especially of the nervous system, found support in the belief once held by German thinkers that if the brain of a man could be severed into two hemispheres, each being left capable of functioning, then the man's consciousness would be divided into two consciousnesses, and that, conversely, if the brains of two men could be bridged over and functional continuity of the cells established, their consciousnesses would fuse together. So the argument for the collective consciousness of a society consists mainly here in the analogy between an organism and a society; but the analogy is defective, for the essential condition of the fusion, if it happens at all, of the consciousnesses of the cells is their spatial continuity but no such continuity of substance exists between the members of any human society.

According to Durkheim there are two orders of representations: those constituting the individual mind and those constituting the collective mind. The primary phase of the individual mind consists in sensations which Durkheim notes is the product not of a single cell but of several in mutual interaction. Sensations thus produced may be further compounded to give rise to images, and these in turn to other higher individual representations. Believing in this hierarchical order of mental products, Durkheim assumes that the collective representations are compounds of individual representations. Durkheim claims that the collective consciousness is 'exterior' and 'superior' to the individual and thereby 'coercive' upon individual behaviour. So, according to him, collective consciousness is the highest form of psychic life, and society is the real god. Durkheim's insistence upon the sharp distinction between

what is individual and what is social in human psychology seems to be based on the belief that 'man is double' in his mental life. He seems to think that individual and collective representations coexist as two beings within the mind of the individual. Durkheim's extreme collectivism has led him to the deification of society almost to the complete disappearance of the individuals.

McDougall thinks that the group may become infinitely superior to any one individual or any mere sum of the individuals that compose it. Maciver goes positively against this misleading doctrine of the super-individual mind of society. The alleged superiority of the social mind is not only not essential for a conception of the mind itself but is rather ambiguous and dogmatic. The group decision cannot as a rule be regarded as intellectually and morally superior to the decision which the best members of the group could arrive at in isolation. As a matter of fact, each may become less than himself, less critical and more suggestible if a wave of emotional agitation sweeps through the group. There is a considerable tendency to change one's opinion as a result of discussion, but the females, South observes by experiments, profit more by this discussion than the males. Practically we observe that the number of jurors is increased to decide cases of murder while to keep the look-out for the safety of the ship only one man, and not ten, is employed. If it be true that the weight of responsibility that would be felt by any one man deciding alone is likely to be divided among the members of the group and weakened in proportion for each man, the individual verdict of the jurors acting together will be less responsible and more lightly and easily arrived at. So there is some truth in the belief that but for the diminution of the sense of responsibility man can hardly condemn another to death. Is then the group or committee decision only an intellectual necessity to avoid the crushing weight of high individual responsibility ?

McDougall's collectivistic view of human behaviour is a somewhat inconsistent superimposition upon his individualistic approach as outlined in his *Introduction to Social Psychology*. McDougall, regretting that his predecessors and contemporaries had to start on a voyage of exploration of societies with an empty trunk or with only a makeshift equipment, decided to pack his trunk carefully before starting. So his *Group Mind* should have been a necessary sequel to his *Introduction to Social Psychology*; but his outlook was altogether changed in his procedure, and he seemed to have left behind the carefully planned equipment of individualistic categories which he established in his preliminary work, and set about practically anew or in much the same sort of makeshift fashion that characterized the work of most of his predecessors. In fact, a good deal of his packing from individual lives remained more or less useless in his dealing with social life.

McDougall points out that each man is a unit in a vast system of vital and spiritual forces, and has but little significance when considered apart from that system. This system of forces is made up of the mental activities of the present and of countless past generations and forms a medium for the growth and operation of the individual mind. The medium becomes in fact an intrinsic part of the mind. So the mind within it and the mind without it are different; the former is normal, the latter incomplete. It is hardly true that the individual mind is lost, and in its place a super-individual mind arises in a crowd or an association. Whatever be the difference of behaviours of the individual in the association and outside it, it is still the individual who thinks and acts. The so-called collective mind is but a particular phase of the individual mind which develops in interrelations of individual minds. This phase is an outgrowth of the individual mind and is coexistent with it. The individual mind is composed of many such special outgrowths. For instance, man's religious consciousness which is studied in Psychology of Religion is a similar outgrowth in relation to unseen powers in whose existence he believes.

A distinct group mind as McDougall assumes favours the possibility of many such group minds or the principle of multiple group-consciousness of the individual as he belongs to this or that group or organization. But the social outgrowths of the individual mind, however differentiated in inner phases through varied experiences, possess as a whole unity and concreteness like the discrete processes of the individual mind. While the existence of social products in the form of social institutions is generally admitted, the social character of mental processes is denied. But this distinction can hardly be justified, for mental processes are expressions of the psycho-social nature of the mind of an individual. The individual is more a social outcome than a social unit. The child's world is at first not a physical world but almost entirely a social world, and it is later on that its consciousness becomes individualized by the gradual acquisition of personal experiences. The mental development of an individual consists not only in the addition to the sum of personal memories but also in the widening of social relations and accentuation of social consciousness. When primitive peoples come into contact with persons belonging to other groups they know them not so much as particular individuals as representatives of some groups, and their deeds as representing group-attitudes. In themselves too, although individual self-consciousness exists in connection with their individual names, private property, leadership, etc., yet it is greatly dominated by the group spirit. Individual self-consciousness develops with the development of intellect. This is true of children as well as of primitive races. But the group consciousness which develops with the development of individual self-consciousness is rational and becomes an

outgrowth of that individual self-consciousness in which the individual life finds its perfection. Social consciousness follows almost a cyclic order of development in individual life. Individuals begin not a personal life first, but an unconscious social life of family traditions, customs, etc. and develop personal life in interaction with and in individual modification of the social life with the aid of a developed intellect. The unconscious social life of the individuals does not, of course, naturally develop into the spirit of higher social life but it forms the nucleus for the growth of national sentiment. So the consciousness of the family group prepares the child's mind for and accentuates the development of wider group sentiments. McDougall believes that the family sentiment and the national sentiment are equally strong in Scotchmen, especially the Highlanders. The family sentiment is very keen among the Japanese who are also noted for their high national spirit. This is also true of Germany and Italy. The people of East Bengal are noted for their nationalistic outbursts, but their sentiment for the joint-family system is also highly remarkable. The importance of the institution of the family life for the welfare of the State, especially in its material aspects, is often insisted on, but the mental effects of the family life in relation to the foundations of national sentiment are no less important. Although any vital connection can hardly be established in view of the low sense of nationality possessed by primitive people in spite of intense family sentiment, still it is probably true that any barrack system of rearing up state children, if introduced, would be disastrous to the growth of national life.

But the family has sometimes been regarded as a barrier to the growth of wider social interests. It is because of a lack of expansiveness that family ties are looked upon by Plato and others as serious obstacles to the foundation and maintenance of larger groups, such as the nation and still more the mankind. According to psycho-analysis of recent years some real antagonism probably exists between family sentiments and social sentiments. But this antagonism does not in fact necessarily exist. There are stages in the development of sentiments which, in order to reach the higher stages, must pass through the lower ones. In the stages of its higher development social interest passes in relatively small steps from the more natural and instinctive to the more complex and cultured. This kind of transition is also in harmony with the psycho-analytic doctrine of displacement and sublimation. So there is no reason to find in the family a natural menace to the development of wider social feeling. The family plays a very significant part in the first arousal of the desires and feelings that bind an individual to his fellows. But the family sentiments prevent the formation of wider social interests only when they remain permanently attached to the narrow circle of the family, other-

wise the family sentiments constitute an essential stepping stone to the formation of the social sentiments. Unless narcissistically fixated and concentrated, they aid rather than impede the development of higher social sentiments.

A vast uncertainty still remains regarding the ultimate elements of social interests. Freud claims that the group spirit springs as a reaction formation from what was originally jealousy or envy. According to him the social ties grow on the dual basis of hostility to the father of the family and of sexual abstinence. So the social impulse comes out of the sexual impulse inhibited in its aim. Of course, there may develop some sexual jealousy ; but it is not very clear by what influence the impulse is supposed to be inhibited and why, being inhibited, its nature should be transformed into its opposite. Besides, the natural result of obstruction to the sexual instinct would seem to be anger as we see in animals. The other view is that the gregariousness of the social nature of man is due to the operation of a special gregarious or herd instinct. I have tried to show elsewhere that gregariousness is not the outcome of a single impulse but of many impulses of life acting together.

The 'social' is, in one relation, an interest in the social life and the social structure as a whole and, in another, an interest in the individual human beings of the society. So interest in others, however differently developed with the development of reason, is the essence of all social processes. This interest may be the operation of a rational will but it is not an exclusive property of a single impulse. To Lester Ward the mechanism of social interests seems to be not instinctive but predominantly rational. According to Boris Sidis man is social because he is suggestible. The most valuable feature of Sidis's contention is that he calls attention to the undoubtedly intimate relation between gregariousness and suggestibility. But he looks upon suggestibility as the result of a disaggregation of consciousness, as a disreputable and disastrous legacy of the brute and the savage, undesirable in civilized life, instead of as a necessary and abiding quality of every normal mind. So his subconscious mechanism of suggestibility is greatly open to criticism. Tarde's 'imitation' or McDougall's 'sympathy' is no less important than Sidis's suggestibility for the growth of social life. The truth is that imitation, sympathy, suggestibility, herd instinct, fighting instinct, sex impulse, parental feeling, etc.—of which human nature is constituted and each of which is separately emphasized as an exclusive factor of sociality—all imply interest in others and develop by their operation a rudimentary but fundamental social substratum. Instinct-impulses are basically a matter of biological as well as social heredity. They are social in the germ, so to speak, in consequence of the fact that they are socially defined, conditioned and directed and by virtue of the social atmosphere in which they function and come to concrete

expression. Faris suggests that they are social products, not biological data. Cooly states that human impulses are not first biological and then social; they are 'socio-biologic' from the first. So this social substratum begins with the impulsive processes of life and is fashioned, as it grows on their co-ordination, by social tradition and reason.

Thus life is in the first instance a social life which grows unconsciously; but when the spirit of criticism develops the unconscious social life begins to be modified by conscious effort and in this way the social life is individualized. We observe personal life is comparatively unknown to the savages. They live a collective life, and solidarity rather than free co-operation characterizes their actions. This racial feature is recapitulated, however incompletely, in the mental development of the individual. This is an inherited phase of the inner life of the self. The social heredity, that is, the body of beliefs, usages, sanctions, etc. which we call culture, is administered to the growing minds by example, precept and discipline, and works out its stupendous social influence. Language, play, art and craft, architecture, etc. are not only conveniences of life, but they are necessary means of intellectual growth. The child-mind grows in feeling by sympathy, in knowledge by imitation and in will by play, assertion and submission, by opposition and obedience. It is through the operation of impulses that the child learns the use of social culture—speech, writing, manual skill—and stands at this stage almost undistinguished from others. But the mental individual is born through the independent use of the social culture. It is a slow growth, the stages of which show the interaction of the individual and the social factors and mark the gradual differentiation of the new individual. So the child is not an individual when he enters into the society but he grows into an individual by social interaction. The outline of the individual gradually makes its appearance, and at every stage it shows the pattern of the social culture of which he becomes a specification.

Progress consists in the differentiation of the more or less undifferentiated social units. Individual progress is only the distributive aspect of what the social progress is and maintains a constant relation to the latter. Individuals are to distinguish themselves from the traditional culture, adapt themselves in better ways to their environment not by ignoring the social forces but by examining and controlling them as fully as possible. So social progress consists in the multiplication, variation and refinement of the culture. The consequent miseries, if any, are only its necessary accidents. Individuals are largely moulded by social culture, but culture in the last analysis comes from the individuals themselves. So individuals should be not merely static conformists to but creative artists of culture. A non-creative personality or a culturally passive mass is a failure,

educational as well as social. So all social and political associations and relationships should be fostered or abolished according as they help or hinder cultural ends.

Cultural differences of people depend greatly upon their mental divergence which is primarily conditioned by differences of physical or social environment, spontaneous variation of mental structure and the crossing of the races. M. Boutmy contrasts the art of the Nordic race with that of the Graeco-Latins elaborately and attributes the difference of the classic and the romantic qualities that predominate in all arts of the South and the North respectively to the influence of climate: the mystical, reflective, introspective quality of Northern art to the foggy atmosphere and the clear direct appeal to the senses in the South to the clear, sunny atmosphere. T. H. Buckle claims to show that the peoples of the various regions of the earth are moulded by their physical environment like so much soft clay. In India and the greater part of Asia the astounding magnitude of the objects, viz., the huge mountains, immensely big rivers, boundless plains, dense forests, dangerous animals, etc. and the appalling character of the devastating forces of nature, such as great floods, violent storms, deluges of rain, earthquakes, etc. to which men are often exposed and which render futile their best efforts to cope with them, stimulate, said Buckle, their mind into grotesque fancies and at the same time discourage any attempt to understand or control them. So in the arts, the literature and the religion of India we see a dominant tendency towards the grotesque, the enormous, the fearful; we see gods portrayed with many arms, with three eyes and terrible visages. The laziness of the Malays, the violence of the Arabs and the Sikhs and the sustained endeavour of the Englishmen testify to the effects of climate and temperature on the habits and temperament of a people.

The question whether environmental forces can mould directly the innate traits of a mind involves complicated issues and is difficult to solve. Two races may live for many generations in the same climate and yet remain very different in temperament. The variation of the innate qualities may develop spontaneously or come out of some racial intermixture. There is some evidence that the crossing of closely allied stocks does conduce to increase of vigour and energy of mind and body and also to that variability of the stock which is generally recognized to be a necessary condition of the production of persons of exceptional endowments. Departures from the average type of mental ability may be by excess of development as well as of defect. So there may not be any increase of the average ability of the peoples of the blended variable stocks; but still men of exceptional character are far more likely to be produced among them than among the homogeneous people of equal average mental capacity. The Chinese have a high average

ability and are a relatively pure race, but their culture has stagnated for want of men of exceptional capacity. So the rigour of the exclusive caste system for the maintenance of the purity of blood is not biologically sound, and the psychological motives of desire to rise in the social scale and fear of falling back, which are two strong spurs to effort, are both absent. But again the crossing of widely different stocks is supposed to produce an inferior race. Thus the Eurasians of India are said to be of a comparatively poor type. According to the Mendelian doctrine of heredity, there can be no true blending of the unit qualities of the parental stocks, but on the other hand the unit qualities inherited from the two parents may go to different descendants. If the individual of a blended stock is a mosaic of such unit characters, any universal characterization of the Eurasians is probably risky. The cross-bred may approximate to the white level in proportion to their share of white blood. So it is not impossible that race-blending improves the inferior race. Of course, such improvement is not desired if the racial qualities belong to a decadent superior race. The mediocre abilities of the modern Greek people are due to substitution of one racial stock by an inferior one. Even the comparison of the physical features of the modern with those of the ancient Greeks testifies to this change. But the people, although by blood radically changed, continues to regard itself mistakenly as the same people. So continued progress or regress of certain mental qualities of the people depends largely upon social selection. The creed of celibacy of the Sanyasins and of persons who are by nature most religiously minded forbids them to transmit their natural piety to descendants. This rigorous process of negative selection is in itself socially irreligious. But the culture that the spirit of religious sacrifice develops is highly fertilizing. Benjamin Kidd denies all importance to changes of innate qualities, whether for better or for worse, and claims that the social heredity transmitted through social culture is infinitely more important to a people than any heredity inborn in the individuals thereof. Anthropologists also recognize that the average skull capacity of the men of the late stone-age in Europe was equal to or greater than that of modern Europeans. So the superiority of modern people consists in the superiority not of their innate powers but of their intellectual and moral traditions and culture.

Sumner suggests that social or racial prejudice is based on recognition of differences. So the remedy consists in their effacement. But there is no reason why such recognition should, in itself, breed animosity and be incapable of attraction and friendliness. Prejudice simply because of difference does not exist. There is no feeling of hatred between the Spaniards and the Indians in spite of differences in colour, speech, habits and dresses. But it comes about when this difference frustrates the

self-determining impulses and wishes of the individuals. So the difference is only an element in the total situation; sometimes it may be only a symptom and not a cause of the disease. The main determinant consists in the baulked impulses of the politically, economically and culturally dominated group. If the inferior or minor group accepts the dominance of the superior or the major group placidly, no change in relative equilibrium occurs. But when the minor group assumes an attitude of equality or superiority through achievements in education, industry, commerce or other vital fields, it imperils and threatens the status and prestige of the major group. So the fear of the loss of status works latently or is aroused easily in the major or the superior group as a consequence of real or fancied aggressions by the minor or the inferior. Thereupon petty annoyance or severe oppression may commence. The antics of the Ku Klux Klan were not measures directed merely against 'differences' but against the real or fancied aggressions of the 'upstart, presuming nigger' for equality. The Chinese are hated in California whereas in Ohio the prejudice against them is very weak. The oppression of the Jews in Germany can hardly be adequately attributed to the apparent difference in their basic modes of social reaction or to the maintenance of the purity of the Aryan blood which is eugenically unsound. The rising superiority of the Jews who are not integral units of Germany is not pleasing to the Germans. Mere difference fails to explain the dynamic character of the social prejudice. Differences are emphasized because they offer the readiest rationalization for defence against real or fancied dangers. It is for the accentuation of the dynamic relation that the Hindu-Muslim tension exists. The policy to multiply such relations of a group with other groups is destructive of its vitality.

When there is a tension in the individual mind against an emergency situation its relief is effected by well-adapted responses; but when such responses are impossible, the individual may suppress the tension. But failure of suppression results in growth of fears which are compensated for by aggressive extrovert behaviour in the form of extreme boastfulness, egoism, persecution of weaker individuals, etc. This process is significant for a thorough understanding of the phenomena of racial and communal prejudice. When any tension occurs between the dominant and the dominated group the reaction may aim at the immediate extermination of the threatening force or the restoration of the inter-group equilibrium; but failures may upset the unstable neurosis mechanism with its attendant persecution devices. In civilized societies the endeavour should be made differently for the stable resolution of such tensions. History shows that men cannot be made to change their opinion by direct coercion. This is an instinctive mode of reaction in which the end is directly aimed at and which is

characteristic of the lower order of animal behaviour. Reason works through stratagem in a round about way. The strategy that reason is to employ in liquidating the baulked impulse of social prejudice should operate far remote from the end and will prove efficient in proportion as it operates unconsciously of the goal. This very remoteness of the measure of the social process is the cause of its great efficiency. This is somewhat of the nature of a weight the power of which, when thrown on the longer end of a lever, is multiplied in transmission. Gandhiji's Satyagraha movement to stop the drinking habit of the masses fails because of its clear and direct attack upon the end. Improvement of conditions, introduction of good music, drama, education, etc., would, however slowly, have produced a more stable effect. So legislation often fails to effect social amelioration. In flattening a warped iron plate strokes are to be judiciously administered at first outside the warped part, otherwise new defects would be produced. Should we think that humanity can be more readily straightened than even an iron plate ?

SECTION OF PSYCHOLOGY

Abstracts

Social Psychology

1. A psychological study of the aristocratic and democratic principles of social organization.

A. R. WADIA, Mysore.

1. The two extremes of social organization: aristocracy or caste and democracy or communism. Their salient features.

Types of social organization resting partly on the aristocratic principle and partly on the democratic, e.g. democracy in ancient Greece and modern representative democracy.

2. Conflicting elements in human nature and the resulting tussle between the aristocratic and democratic principles.

3. This tussle illustrated by a review of instincts, emotions and intellect and also by the psycho-analytic view of the unconscious.

4. A study of the instincts of pugnacity, curiosity, self-abasement and self-assertion as bearing on the problem.

5. Gregariousness and sympathy. Jealousy and sex instinct.

6. A brief account of the contrast between the caste spirit and the spirit of Russian communism. Both tend to be rigid and lose the spirit of freedom. The psychology of the love of freedom and the love of equality.

7. What guidance can Psychology give us in social reconstruction?

2. The Bratachari movement: Its psychological and educational significance.

G. S. DUTT, Calcutta.

Bratachari comprises the following factors :—

1. A cosmic idealism based on rhythm, joy and the unity of all life.
2. A humanistic idealism based on international fellowship.
3. A cultural nationalism based on the pursuit of regional culture.
4. A code of citizenship based on both international and regional ideals.
5. A cult of individual and social duty and social service.
6. A cult of complete physical fitness.
7. An earnest discipline for the formation of character.
8. A harmonious development of body, mind and character by a simultaneous rhythmic discipline.
9. A cult of the practical expression of the dignity of labour and particularly of manual labour.
10. The restoration of the faculty of simple artistic self-expression to every human being.

The movement seeks to harmonize religion, science, philosophy, art, work, leisure and joy by means of a simultaneous rhythmic discipline

directed towards the pursuit of the inclusive ideal embodied in its fivefold Brata of Knowledge, Labour, Truth, Unity and Joy. This complete harmonization of life leads to the real joy or *Anandam* which is the goal and consummation of life. It also seeks to remove the compartmental treatment of Education and of Psychology and the other sciences and to impart a wholeness of ideal to life and a synthetic discipline for its realization. It is adapted to the needs of persons of both sexes, irrespective of age, race, nationality and religion.

Abnormal and Clinical Psychology

3. Opposition between wishes.

G. Bose, Calcutta.

Wishes may be classified under several rubrics according as they are active or passive, objective or subjective, egopetal or egofugal. In active situation the subject does something and feels the urge as a *wish*. In passive situations he wants something to be done to him. An objective wish concerns itself with an object outside the subject's ego. A subjective wish arises with reference to the sensations of the subject himself. An egopetal wish is one in which the direction of interest is towards the subject whereas in egofugal wish the person is interested in the object. Grammatically speaking, the nominative denotes the direction of interest. Activity is opposed by passivity and egofugal interest is opposed by egopetal one. There is also a mild degree of opposition between an objective and a corresponding subjective wish. Generally speaking, it may be said that the opposition between two active or two passive wishes is only possible when there is an opposition between an egofugal and an egopetal interest and even then the opposition is more marked between corresponding active and passive wishes when the direction of interest remains identical. The opposition is absolute between corresponding active and passive wishes when the direction of interest in the two wishes is also opposed. The last form of opposition is the most important one in *repression*.

4. Study of certain characteristics of delinquent boys.

J. M. Sen, Calcutta.

(1) Investigation at the Reformatory and Industrial Schools at Alipore started under the Bengal Children Act of 1922.

(2) Primary consideration in any investigation of delinquency is the causation—family history—environment in which brought up—poverty of outlook and wealth—factual material—age at entrance—length of stay—religious affiliations—province of origin and languages spoken—environment at the institution to which sent.

(3) Comparisons of I.Q.'s of a few delinquent boys with those of general population.

(4) Statistical techniques and their applications in an attempt to understand the significance of combination of factors in relation to delinquency.

(5) Problems presented by the boys of the Reformatory and Industrial Schools.

5. Teaching of arithmetic to mentally deficients.

S. S. Sinha, Calcutta.

The paper reports the partial success of an attempt to teach basic principles of elementary arithmetic to two mentally deficient boys of age 13 and 15 respectively.

6. Occupational therapy and its application to a few important occupations in a mental hospital.

A. K. MUKHERJI, Kanke.

1. Meaning of occupational therapy and the difficulties of its application.

2. Craft work is the usual medium of occupational therapy. But occupation is not restricted to crafts alone. Games, music, physical exercise, reading, picnics, amusements, etc. are quite as important.

3. Advantages and disadvantages of different kinds of occupation. They are differently suited to different types of mental disorder and are to be used very carefully.

7. Cardiac neuroses and their physical basis.

J. N. MAITRA, Calcutta.

In our clinic we get a variety of cases complaining of bona fide cardiac symptoms, but on analysis we find by X'rays and electro-cardiograph that a large majority may be dismissed with a single word of re-assurance telling them that the complaints have no discoverable lesion in the heart.

Very recently a series of cases have been discovered with heart complaints and these may be compared to cases of hysteric fits in women who get early eclampsia or ovarian tumour in an early stage. Removal of causes of toxæmia removes the hysteria. In a number of heart cases clinicians dismissed many of these cases as neuropathic, but on further following up, these cases were found dead suddenly. Two such cases have been recorded by Vaques Laidlaw in France who held post mortem examination of these cases and found absolute blocking of lumen of coronary arteries. One was 62 years old and other 18 years old. There are many remedies, but I have found that physiological anoxæmia induced either by holding the breath properly as done by *Pranayam* or that chemical anoxæmia as induced by 2% solution of hydrocyanic acid 2 drops every 12 hours taken by mouth in water has cured my series of cases.

So, before dismissing cases as malingering or neuropathy or incurable functional neurosis we physicians should properly investigate these cases and cure them before they are dead.

8. Freudian categories in the light of structural psychology.

RAJ NARAIN, Lucknow.

The suggestion for this paper came from a study of Wundtian principles of Fusion, Assimilation and Composition.

In his theory of dreams Freud advances a number of categories which seek to decide the various mechanisms in the dream-consciousness. They are: Condensation, Dramatization, Displacement, and Secondary Elaboration. These categories *ipso facto* apply to day-dreams also. Freud, however, formulates the categories of Identification, Projection and Symbolization to explain certain forms of neuroses. Not only that. Freud believes that some of these categories are operative in everyday life.

The purpose of this paper is: (*a*) to analyse the essential features of the above mentioned modes of transformation of mental states, in order to (*b*) discover how far these modes can be interpreted in terms of the principles proposed by earlier psychologists. That is to say, the paper aims at exhibiting the influence of Structural Psychology on the origin and development of Freudian concepts.

Psychology of Indian Thoughts and Religion

9. Psychology of Yoga.

S. P. Aranya, Faridpur.

An attempt has been made in this paper to determine the relation of Sattwaguna (supra-liminal consciousness), the acme of Raja-guna and the sub-liminal consciousness of Tama-guna to Para-Vairagya (supreme detachment).

10. Psychology of Nirvana.

S. P. Aranya, Faridpur.

Nirvana means complete cessation of all modes of consciousness. It is an attainment of unconditioned peace. Buddhistic doctrine does not support the idea of different stages of meditative attainments. In Nirvana a state beyond mind is attainable.

11. Psychological elements.

S. P. Aranya, Faridpur.

The analysis into cognition, feeling and conation is wrong. Such analysis involves a hybridity of thought and confuses the knower and the known. The writer has tried to establish this idea by psychological thoughts of the ancient literature of the Hindus.

Psycho-Physics and Mental Tests

12. A note on forecasting value of intelligence test.

P. C. Mahalanobis, Calcutta.

In 1935 a group test of intelligence was given to 263 first year students and 187 third year students of a first-grade college in Calcutta along with the college annual examination. About a year later most of the students sat for the college test examination and a little later for the Intermediate or the B.A. and B.Sc. examinations of the Calcutta University. Marks obtained by the students in the college annual and college test examinations were collected. Information was also collected regarding success or failure at the university examinations. The present note discusses how far the results in the college or the university examinations could have been forecasted from the scores in the intelligence test.

13. A comparative study of the intelligence-scores of boys and girls in the first year class.

S. S. Jalota, Lahore.

Shortly after admissions in June 1934, a number of 1st year (Post-matric) students were tested at Lahore. This paper reports the analytic study of 272 pupils (114 girls and 158 boys). The boys do better in number series, and analogies. The girls show better in reasoning (Burt's modified). In the other test-elements, the superiority of the boys is not significant.

The boys' group however shows a superiority in Marticulation marks. Hence, the girls' scores were *attenuated* to counter-balance the effect of disparity in group-selection. Now, the girls show a superiority in instructions, classification and cancellation. The boys continue to hold

their own in memory, best answers, and logical selection (Terman's). The differences, however, are not significant in either case.

These results are compared with the findings of E. W. Menzil and V. V. Kamat.

Theoretical Psychology

14. Explanation of synæsthesia.

S. K. Bose, Calcutta.

Criticism of the notion of sensuous heterogeneity and that of Helmholtz's assumption of complete disparity of sensations. The unsatisfactory nature of current theories. Emphasis on the hypothesis of the continuity and identity of sensory qualities. Study of the facts of intersense analogy from a new point of view. Review of the cases of synæsthesia reported by Myers, Banerji and Wheeler. Discussion of Hartshorn's view and results of Karl Zietz's experiments. Similar experiments for inducing synæsthesia on normal persons. Advantages of the new explanation.

15. Influence of different types of materials on memory.

H. C. Banerjee, Chunilal Shaha, *and* R. N. Ghosh, Dacca.

An experiment with the help of an instrument 'Mullers Kymograph, apparatus' was carried on with a view to determining whether memory ability is specific for the type of the material learned or quite independent of it. Sixty students of classes VIII, IX, X of the Armenitola Government High School and ten teachers-in-training were tested. Six different kinds of materials were used, e.g. nonsense syllables, common environmental words, picture series, arithmetical numbers, historical dates and arithmetic sums. Each series was composed of 7 units which were written on a rolled piece of paper at equal distances of 3 inches from one another. The experiment shows that the correlations between different series were low. This indicates that the influences of different types of materials upon memory are specific.

16. Vierordt's law and tactual estimation of distance.

K. C. Mukherjee, Dacca.

In this article an attempt has been made to establish a definite relation of Vierordt's law to the tactual estimation of two-point distances. Besides, some biological significance of the relation is suggested.

17. Memorization by serial anticipation method.

H. P. Maiti, Calcutta.

In experiments on memorization by the learning method, as advocated by Ebbinghans, reproduction is guided by no definite instruction as to the direction of association between units. As a matter of fact, the subject takes the help not only of forward but also of backward and remote associations in acquiring the given material as a finally organized whole. Individual subjects differ as to their subjective procedure in this respect, and this explains to a great extent the varying number of presentations required by different subjects for the complete mastery of the material.

In the study reported here the subject is required to reproduce serially by anticipation each unit before it is presented, after he is

familiarized with the whole series of the syllables in an initial presentation. He is thus forced to rely mainly on the factor of forward association for acquiring the given series.

The same subjects took part in memorization of nonsense syllables by the ordinary learning method and the method of serial anticipation outlined in the paper. A comparison of the memory scores as well as of the introspective data throws interesting light on the nature of the memorization process. The paper ends with pointing out certain bearings of the study on our conception of memory.

18. Mahammad as a mystic.

RAJ NARAIN, Lucknow.

A psychological account of a mystic life is given in the article.

Intelligence and 'Factor' Psychology

19. Intelligence—its nature and measurement.

D. NORONHA, Shillong.

There is more agreement as to who is intelligent than as to the definition of intelligence. The common ground between Thorndike Binet, Terman, Spearman, and others—intelligence is only one factor in general ability. As manifested in the processes of learning it can be measured, and their measurements can be used as the basis of forecasts.

20. Intelligence tests and their value in education.

D. NORONHA, Shillong.

Intelligence tests have many limitations but when carried out accurately and interpreted with care they make it possible at the age of 7 or 8 to forecast with an accuracy sufficient for most practical purposes, whether an individual will be able to enter college or compete successfully in the professions. A description of how intelligence tests are built up. Single test and batteries of tests progress from the days of Simon-Binet to to-day. A word on aptitude, achievement, volitional and emotional tests. The significance of tests in education : their tremendous potentialities for the future.

21. A test of 'general ability' for use with Indian children.

K. G. R. RAO, Madras.

The paper describes a new series of non-verbal tests of 'general ability' devised by some of Spearman's students.

The verbal and non-verbal tests now in extensive use have been criticized both on psychological and statistical grounds. Recent researches upon language ability and V-factor have proved that verbal tests do not give a critical measure of 'intelligence'. The 'anarchic' nature of the non-verbal tests can be gathered from the utterances of Thorndike, Pintner and others.

In marked contrast to these empirically chosen tests are the non-verbal, primarily perceptual tests. They are constructed with spatial-perceptual material, and involve as many classes of cognitive relations as are amenable for easy and effective measurement. They fulfil the most exacting requirement of the theory of two factors.

The development of primarily perceptual tests marks a step forward in the progress of the study of individual differences: (1) They supply a measure of eductive ability free from gross or critical experimential influences. (2) They can be applied with success to peoples of almost

every nation, race or culture. (3) Their use as a standard or 'reference' in factor studies is suggested.

22. The measurement and nature of language ability.

K. G. R. Rao, Madras.

The paper concerns a statistical and consequent psychological study of the factor content of verbal tests.

The basis of the study is a theory of factors, i.e. a theory of factor analysis of correlations.

Recent work has isolated a group factor, named non-committally 'V'. The present enquiry claims to give information about (1) the magnitude of the factor or factors entailed in all verbal tests; (2) the dependency upon speed and quality; (3) the relative significance of selective and inventive type of tests; (4) the psychological nature of the factors; (5) value of verbal tests as serviceable instruments in schools.

The primarily perceptual (non-verbal) tests of 'general ability' are used as 'reference' values.

An unselected population of 200 boys supplied the needful data. The age range of the children varied from 10 to 14 years.

The final result of the work is to suggest that (1) the broad factor 'V' is almost as fundamental and as important as 'g' measured by the p.p. tests; (2) speed but not power is a disturbing factor in all tests; (3) inventive and selective tests are alike in factor content; (4) scholastic influences and verbal fluency may contribute to V-factor, but do not explain it; (5) the V-factor is probably dependent upon an 'associative' ability.

23. Can children between 6 and 8 years assume hypotheses to do formal reasoning?

S. B. Gupta, Calcutta.

Number of children—55. *Procedure*—I read the absurdity tests of Binet Simon one at a time to a child and asked him whether there was anything silly in it. It was often read more than once if necessary. I took down the answers immediately, given by the child, so as not to lose a single word, later on analysed and compared the answers and arrived at conclusion.

Table below will show the percentage of correct answers given by my group of children and we must at the same time remember that these children were between 6 and 8.

Table.

1.	Poor cyclist	26·6%
2.	Young girl	20·3%
3.	Friday	7·4%
4.	Engine-driver	62·2%
5.	Road to the city	65·5%
6.	Three brothers	44·4%

Analysis of children's answers.

Answers were grouped under the following headings :—

1. Correct.
2. Nothing silly.
3. Nonsensical.
4. Moralization.
5. Repetition.
6. Refusal.
7. Refutation.

Conclusion.

(1) A good number of children at this stage are able to understand the premises given.

(2) They do not question the legitimacy of the given premises, but admit them.

(3) Some find and some cannot find the contradiction in thought.

(4) Those who do find cannot always express themselves logically. Hence, the difficulty is not only of reasoning but of expression.

(5) Some not only understood the contradiction in thought but stated the reasons in such a clear and methodical way that they needed no further verification.

Educational Psychology

24. Bright children, their nature and education.

S. K. Dutt, Dacca.

Scientific treatment of the problem of education of children of superior intellectual powers dates from the 19th century. Problem was approached through the study of the achievements of eminent persons of the world in the absence of any reliable methods of quantitative measurement of intelligence. Study was thus limited to adults. Sir Francis Galton was a pioneer in this field of study—Ribot, William James, Woods, Havelock Ellis, Yoder and a host of other eminent psychologists studied different aspects of the problem.

The experimental education of the gifted children began only after the war. Binet's epoch-making work of discovering the intelligence scale has given a powerful stimulus to the problem. In 1919 was founded Research Fellowship in San Francisco for the study of gifted children. In 1921 Directors of the Common-Wealth Fund made a special contribution to Stanford University (U.S.A.) for the extension of research in this field.

In Britain Cyril Burt called public attention to the problem of the education of bright children. Prof. Whittekar of the University of Edinburgh drew the attention of the Scottish public to the problem. Lord David Cecil's article in the *Daily Telegraph* (Tuesday, January 7, 1930) urged the paramount necessity of discovering and developing superior intelligence.

25. Individual differences and the necessity for the special education of bright children.

S. K. Dutt, Dacca.

Enormous individual differences proved by experimental evidence. Prof. Godfrey Thomson's experimenting with 2,710 cases in the English County of Northumberland. Individual differences in our school classes will be evident from the records of the examination scores of a particular school given. The results of the mental tests (Goddard Revision of Binet-Simon Tests, 1911) prove it.

Courte's silent reading test given by me to a class in 1927 shows that the rate of the fastest pupils was 229 words per minute equalled more than twice the rate of the slowest which was only 101 words per minute.

The surfaces of frequency curves will show that only a few of the bright and slow pupils are found in each capacity in a single class.

Special provision must therefore be made for the education of bright children to avoid their wasting time.

Classes for the gifted children are formed now merely on the results of intelligence and scholastic tests, but special talents possessed by individual children may still remain undetected—such special talents may be discovered by means of various 'performance tests' (e.g. Seashore's tests of musical ability, etc.) and should be developed through proper training. Suggestions for the special treatment of 'talented' and 'gifted' children.

26. Some experiments in stimulating oral expression in English.

K. D. Ghose, Dacca.

The experiments were tried at the Ballyganj Government High School in Calcutta for a period of about two years—they are carefully graded in difficulty for Classes VI, VII, VIII and IX and the age of the boys varied from 11 to 14—the psychological background of all 'expression' work—fourfold aim of the experiments—freedom, joyousness and facility of expression coupled with precision and accuracy in statements—the experiments :—(*a*) Orders and Commands, (*b*) Dumb Acting, (*c*) Reading and Acting of a Play, (*d*) Dialogues, (*e*) Speeches, (*f*) the Hammer, (*g*) Spinning of a story, etc.—the experiments do not involve any costly apparatus nor do they interfere with the ordinary routine of the school—the procedure that was followed in connection with each of the experiments—the results.

27. Common errors in English pronunciation of Bengali boys —their causes and remedies.

H. C. Banerji, J. N. Das Gupta, V. K. Handiekar *and* Kanak Bandyopadhaya, Dacca.

Importance of English pronunciation in the teaching of English. Construction of a test including certain vowels and diphthongs peculiar to the English language and absent in the vernacular and a few consonants which are often mispronounced by Bengali students. Twelve boys of each of the Classes V to VIII of the local high schools at Dacca were tested in these sounds, intonation and stress. These tests prove :

(1) Pronunciation in vernacular affected in a remarkable degree the English pronunciation.
(2) The pronunciation of diphthongs registered the highest percentage of mistakes.
(3) Very few pupils could pronounce the 'z' sound.
(4) The sounds produced lacked resonance which is a distinguishing feature of English pronunciation.

Some remedial measures have also been suggested.

28. English spelling ability of Bengali boys.

H. C. Banerjee, Dacca.

Discussion of the results of an investigation into the typical errors in spelling in English of school boys. Errors found were due to ignorance, wrong pronunciation of words, confusion on account of non-phonetic nature of the English language, carelessness and hurry, false analogy, etc. Some remedies suggested.

Criticism of the existing method of teaching spelling. Necessity of appealing to as many senses as possible in teaching the subject.

29. A study of the professional judgment in teaching.

PARS RAM, Lahore.

How is a teacher's ability to form correct judgment on teaching situations related to his academic qualifications, his general informations and his acquaintance with pedagogic literature ? Are there any sex difference in professional judgment on teaching situations ? In order to find out a preliminary answer to these questions Dr. J. C. Manry's 'A professional test for teachers' was given to a group of 51 men and 28 women B.T. students. The Test consists of the following seven sub-tests :—

Test I & II	General information.
Test III	Professional technique.
Test IV	Professional judgment.
Test V	Educational leader.
Test VI	Educational literature.
Test VII	Educational terminology.

Average age of the men students was 25·52 years and that of women students was 24·53 years. 66·6% of the men had taken their Master's course at the time of testing whereas all the women students with the exception of one were only B.A.'s. Again the average scores of men students in Tests First and Second were 20·27 against 19·71 of women students. Inspite of the men's superiority in age, academic qualifications and general information, the women students beat the men students in their scores in Test third and fourth (relating to professional technique and professional judgments) where they score 13·60 against 12·39 of men in test third and 31·25 against 29·49 of men in test fourth. Thus the inquiry suggests that women possess a better pedagogic judgment than men. Inter-correlations between the scores of the various sub-tests are also worked out.

30. The psychology of learning.

D. D. SHENDARKAR, Hyderabad (Deccan).

An attempt has been made in this article to develop some interesting processes of learning.

Feeling and Emotion

31. Is there a general affective value ?

S. C. MITRA, Calcutta.

Spearman's 'G' factor. Beebe Center's study with odours. Similar experiments with ten colours. The method of serial arrangement according to preference. Inter-correlations. The six hundred and odd tetrad equations worked out. Possibility of a general affective value discussed.

32. Studies in 'emotion'. No. 1. Nature of emotion and literary appreciation.

N. S. N. SASTRY, Mysore.

Emotional experience is common. But the consciousness of such an experience is doubted by some. But the *tone* and *mood* relating to emotion are facts. The physiological factors of tone and mood are considered.

The *stimulus-response* idea in relation to emotion must be properly understood. The appropriateness of simulus patterns is essential to the arousing of emotions. Emotions may be the psychological accompaniments of instincts.

Man alone, has, to the greatest extent, the capacity to react to ideational situations possessing the necessary emotional provocative contents. Literature has used many devices to create such situations. The perceiver also must have the capacity to recognize the stimulus-quality of such situations. It is only then that the subliminal instinctive reaction starts, accompanied by appropriate emotional states. The tone and mood of such states is characteristic of literary appreciation.

33. Studies in 'emotion'. No. 2. Differentia of emotion.

N. S. N. Sastry, Mysore.

The vasomotor and psychological theories of emotion do not give us a differentia of emotion. The nature of the problem is here discussed. Fact of emotional experience is doubted by some. Some doubt the normality and utility of emotional experience. The description of the course of the phenomenon shows that utility and normality are not incompatible with the true nature of emotion.

The anticipatory and reflective nature of the phenomenon is discussed. The '*haze*' state of emotional excitement is pointed out. The consequent irradiation effect is discussed.

How does the experiencer recognize the nature of emotion? The suggestion of Landis, Gullette and others is criticized. The proposed differentia of *situation-response* meaning is justified by experience and experiments.

34. Studies in 'emotion'. No. 3. Judgment of facial expression of emotions.

N. S. N. Sastry, Mysore.

Judgment of expression of emotion is sociologically very important. But such a judgment is never of an expression in isolation. It is always in 'situ'. Many previous experimenters have ignored this fact.

Preliminary survey of 'emotional' situations yielded the frequency of emotional content of such stimulus situations. Two tests were built up:—(1) presentation of facial expression along with concrete pictorial presentation of situation, and (2) lingual presentation of situations. The subjects were asked to illustrate the latter test by means of the several photographs of facial expressions of emotions.

The very high correlation coefficient justifies the differentia and the thesis in regard to the meaning of judgment of emotional expression.

35. The psychology of jealousy.

K. D. Ghose, Dacca.

The common psychological causes—adult attitude of disapproval makes matter worse for the child—some instances collected by the writer—is it a case of not so much 'cured' as outgrown?—possible remedies.

Reflex and Instinct

36. Children's fear—elimination through play instinct.

(Miss) S. Ghosh, Mayurbhanj.

Fear is the most disturbing element in children and the worst of all is that its origin and development cannot be properly traced out. Even the parents are ignorant of their children's this emotional aspect. The educator should try to focus their attention on the particular behaviour of an individual child and should find out the family in which the child

is brought up. The child is, in the main, a realist who learns to comfort himself in his world as its nature requires, but he is liable to lapses in which the (fear) complex underlying his normal behaviours loses their coherence. It is a mistake to think of it as an innate tendency. It consists, at first, in impulses, morally colourless, which simply urges a child to suppress his self-regarding sentiment and makes the child feel miserable. The growth of the self we should aim at will give the child a free scope within the common life. Our children learn a large number of subjects through social fear each more or less independently and they too often see little connection with them. The educational system has ceased to be educative. We can look for reforms through minor adjustments (i.e. through play and project). It is always possible to organize significant project and play into a connected series that bears a well-developed conception of the whole past, present and future life and takes away the most disturbing factor fear.

37. Child psychology—play instinct. Rhyme and rhythm in education. Psychological aspect. Sublimation.

(Miss) S. Ghosh, Mayurbhanj..

Our children will realize the highest aim of life through play. Human will is always free and we like to think that our behaviour is our free choice. Individuality develops only in co-operation. All we demand is that it shall have free scope, within the common life, to grow in its own way. Just as the physical sustenance of man and his development in bodily powers depends upon the energy of the sun, daily expending heat and light on organic existence, so our mental and spiritual advance are upon the perpetual renewal of human energy through social experience. If for a moment these influences are relaxed, if man ceases to care for the nurture of the young, then the race 'falls back into the beast'. The past cannot be inherited except through steady effort and discipline. Each new generation has to reshape for itself the whole structure of conscious thought, willing and feeling, of adaptation, which thousand and thousand years of struggle of our ancestry put at our disposal. We stand on common ground when we cherish in our children all that we find of worth in human experience as it has gone from strength to strength. Through million channels of suggestion and control, this impulse keeps contact between the unconscious memory of the individual life and the current experience of the world of here and now. Harmony should be the aim of the educator. The real and true balance—' nothing in excess '.

38. The creative instincts.

Phakirdas Banerji, Dacca.

The word instinct is evidently derived from animal life. Can we extend its meaning and regard instincts as the basic forces of all forms of life animal as well as human ? Most psychologists think, we can and ought to. If so, the further question arises, how is it that of all animals, the sub-human ancestors of men could rise to the eminence of man ? Were they physically the strongest and fittest ?—or was there any qualitative or quantitative differentia inherent in their nature which marked them off from the rest of the animal kingdom ? These are some of the questions discussed by the writer in this paper. He distinguishes between what he calls the creative instincts and the merely life-ministering instincts and holds that the creative urge of life has reached its most characteristic expression in man, in the form of an impulse for adventure. This has led him on from animal life through the many stages of arboreal and caval life to the present stage of civilization which is still to be transcended, for he will still live and create.

39. Deviation of instinct in a domestic animal.

M. N. Banerji, Calcutta.

The paper records the writer's observations of the behaviour of a deer under domestication from the age of three days.

40. Can we facilitate conditioning ?

Udai Bhanu, Indore.

It is needless to say that the contribution of a human organism entirely depends upon conditioning. Then the question arises can we facilitate it ? Is it possible to reduce time and energy ?

The author has attempted to answer this question. This paper is the result of his laborious research in the field.

What is conditioning ? What are the physiological changes during conditioning ? Laws of substitution, fatigue, forgetting, effect of blood on conditioning, effective value of stimuli : these are some of the questions that have been answered. Study of organization is at all new. An effort is made to explain why the neural impulse adopts a particular pathway rather than the whole nervous system. A new theory is propounded upon conditioning.

The description is scientific and in untechnical terms of easy comprehension.

Physiological Psychology

41. Photic phenomena in mystic life.

Raj Narain, Lucknow.

The writer has tried to give a physiological explanation of photic experiences which characterize the lives of all races, regions, cultures and times.

GENERAL DISCUSSIONS.

I. THE AGE OF THE DECCAN TRAP.

Section of Geology and Geography.

MR. W. D. WEST, President of the Section, in the chair.

H. CROOKSHANK (*Calcutta*).—The Deccan Trap fossils have doubtless been a source of speculation in India for centuries, but the honour of introducing them to modern science undoubtedly belongs to Dr. H. H. Voysey, who described land shells in the Trap as early as 1819. The next discovery of importance was made by Capt. Sleeman, famous for the suppression of Thagi, in 1828. He reported 'trees with roots, trunks, and branches, all entire and beautifully petrified, and fossil bones of animals' in the Lameta formation at Jubbulpore. The association of fossil trees with the bones in this classic locality is particularly interesting as Matley at a later date only found bones. In 1833 Dr. H. H. Spry found the remains of palm trees and shells at Saugor, and two years later Dr. Benza noted the important fossil locality near Rajahmundry.

So far identification had lagged behind the discovery of the Trap fossils. In 1837, however, J. G. Malcolmson assisted by Mr. J. de C. Sowerby described the fossils found by the former in the intertrappean beds between Nagpur and Hyderabad. In this classic work they described all the land shells so far found in the traps and also several species of Cypridæ and of Chara which were not known in the trap previously. They finally expressed the opinion that 'the Trap belongs to the Tertiary epoch; but to which period I fear we have not the means of deciding'.

The next observer of importance to be interested in the Trap fossils was Mr. H. C. Carter. His chief additions to existing knowledge were a description of the fossils in the Bombay Intertrappeans, a report on the fossil plants in the Rajmahal Intertrappean beds in which he compared them with the flora of the Indian coalfields, and showed that the latter were older than the plants in the Deccan Trap, a report on the association of the Trap with the Nummulitics in the Rajpipla hills, and a happy suggestion which ultimately led to the discovery of the Bagh beds.

Among the fossils described by him from Bombay occur for the first time a record of frogs, tortoises, and insect remains in the Trap. The great importance of the association of the Trap with the Nummulitics will appear later. Acting on Carter's suggestion T. Oldham urged the political agent of Nimar, Capt. Keatinge, to search the Bagh region for fossiliferous limestone with the result that he discovered the Bagh beds in 1856.

The last addition to our knowledge of the Trap by the early writers is the memoir published by Hislop and Hunter in 1855 describing the flora and fauna associated with the Trap in the Central Provinces. Hislop, to whom most of the field work is due, considered the Lametas and the Intertrappeans to be identical. He thought that the earliest basalt flow was a sill which had split the fossiliferous beds at the base of the Trap into two.

Hislop also described some of the Rajahmundry fossils which a friend had sent him, and showed that they were a mixture of fresh water and estuarine shells some of which were identical with the gastropods of the Intertrappean beds.

As regards the age of the Trap he concluded that the flora and fauna were most like those of the London Clay and the similar beds at Rilly in Belgium. He also expressed the opinion since controverted, without I

think any very good reason, that the Central Provinces and Bombay Traps were homotaxial.

So far geological work in India was mainly in the hands of soldiers, doctors, missionaries, and other enthusiastic amateurs. By their labours they had discovered all the classical fossil localities, and they had brought together an assemblage of Deccan Trap fossils not far short of what we have at the present day. With the assistance of London specialists they had also worked out the fossils, and had reached an extremely shrewd idea of the age of the Trap.

These pioneers deserve the greatest praise for their fine achievement, all the grander perhaps because most of them were servants of 'John Company' whose business in life was the building up of dividends for London directors. This purely trading institution which had the breadth of vision to encourage its servants in the pursuit of pure science deserves our thanks also.

We now come to a period when the elucidation of the history of the Deccan Trap fell almost entirely into the hands of the Geological Survey of India. As was only right the workers now expected the evidence of fossils to tally with their field results. As will be seen this led to a change of opinion on the subject of the age of the Trap. The first results of the appearance of professional geologists were, however, most valuable. They were able to explain to the satisfaction of all the mystery of the occurrence of fossiliferous beds in rocks of volcanic origin. J. G. Medlicott was the first to show that the Intertrappeans were sedimentary beds laid down in quiet intervals between successive basalt flows, an opinion that is now accepted by everybody.

The first member of the Geological Survey to make a careful examination of the Trap was, however, W. T. Blanford. Acting on Carter's information he mapped the junctions between the Bagh beds, the Nummulitics and the Trap. At Bagh he found a slight unconformity. In Gujerat he found a well marked Intertrappean dipping below the Eocene (Middle Nummulitic). Judging from this observation and from the abundance of Trap debris in the Eocene beds he considered that there was an important unconformity between the two series. He concluded that 'the lowest Traps appear to differ less in age from the middle Cretaceous beds of Bagh than the highest Traps do from the Lower Eocene formation of Surat'.

'The evidence', he goes on to say, 'is still far from conclusive, but it appears highly probable that part, at least, of the Traps are upper Cretaceous in age. It is even possible that the lower Traps of the Central Provinces might be Middle Cretaceous. The eruptions which produced them may have continued throughout a long period of geological time, and the uppermost flows of Bombay and Mahableshwar might even have been contemporaneous with the oldest Tertiaries'.

Blanford's views were not at first generally accepted, for we find the Director of the Geological Survey writing in 1871 as follows. 'The geological epoch of these Intertrappean beds seems to be tolerably well established as belonging to the Eocene period of European geologists'; and again 'The evidence against the supposition of Mr. W. Blanford seems, however, decidedly stronger than that in its favour'.

However, by 1879 Blanford's views were officially accepted, for we find them duly perpetuated in the first edition of the manual by Blanford and Medlicott, and in the second edition by R. D. Oldham.

Meanwhile work on the Trap was by no means at a standstill. In 1879 Blanford described Fedden's discovery of Trap at the Bor hill in western Sind. He found one quite definite basalt flow between the Cardita beaumonti beds and the Ranikot stage, and he found some Trap in the Cretaceous about 700 feet lower in the sequence. Assuming that the lower bed of Trap was a flow and belonged to the Deccan Trap series, this would indicate the presence of Deccan Trap flows as early as mid-Cretaceous.

In 1880 W. King published the first accurate description of the fossiliferous beds near Rajahmundry. He showed that there were infra-trappean beds separated from the Trap by a slight unconformity, and also inter-trappean beds. The fossils from the former proved to be mostly marine, those from the latter estuarine. King considered the fossil evidence quite inconclusive, but if anything favoured a late Cretaceous age both for the infra- and the inter-trappean beds.

In 1884 Bose divided the Bagh beds of the lower Narbada Valley into four divisions, the uppermost of which he correlated with the Ariyalur division of Madras. He showed that Lametas overlay the Bagh beds with an unconformity instead of being homotaxial with them as is so often stated. Locally he found Lametas passing upwards into ash beds associated with the lowest flows of the Trap.

Bose's evidence has always been neglected, but it seems to me to point to a Tertiary age for the Traps of the Lower Narbada area, for Ariyalur rocks, which are uppermost Cretaceous, are separated from the lowest Trap flows by an unconformity and by 40 feet of Lameta limestone.

Not till 1906 were any further papers published connected with the subject. In that year Smith Woodward described some fossil fishes from the Intertrappean beds at Dongargaon, and expressed the opinion that they were Eocene in age. This information was hardly in accordance with the official views of that period. In 1921, however, Matley published his paper on the stratigraphy, fossils, and geological relationships of the Lameta beds of Jubbulpore. In this he showed by close mapping that no break could be observed between the uppermost Gondwanas and the lowest Trap flows. He described the various Saurian bones which he had collected in the Lametas within a few feet of the base of the Trap, and expressed the provisional opinion that they belonged to the Albian or Cenomanian, low stages in the Middle Cretaceous.

This was weighty evidence in favour of a Cretaceous age for the Trap at Jubbulpore, and it is not surprising to find a Cretaceous age accepted by Wadia in his Geology of India in 1926. At the same date Holland laid down that ' there can be little doubt that the inter-trappeans as a whole are Cretaceous, and this is very greatly strengthened by the occurrence of *Bullinus* (*Physa*) *prinsepii* in the Mæstrictian of Baluchistan '.

We now reach the last stage of the controversy. In the post-war period knowledge of the natural sciences had so far advanced in India that work of first class importance to science could now be undertaken by the professors and students of the various universities throughout India. It is therefore gratifying to find that research on the part of the Indian universities is mainly responsible for recent advances in our knowledge of the Intertrappean fossils.

Perhaps the earliest of the recent papers bearing on the age of the Trap is the one by Hem Chandra Das Gupta published in 1933. In this he describes and figures specimens of *Cardita beaumonti* collected by him from the Infratrappeans near Rajahmundry. This definitely fixes the age of these beds as very high in the Cretaceous. As King had already shown that there was a slight unconformity at the top of these beds it becomes likely that the overlying Traps are Tertiary. Mr. Rode ' followed in the same year with two papers describing fossil plants from the Intertrappeans of the Chindwara district. Huene and Matley also published an important memoir describing the Lameta bones of the Jubbulpore district. In this they state : ' For the present, therefore, we may take the fossiliferous beds of Jubbulpore to be Turonian '. This diagnosis is higher in the Cretaceous than Matleys' provisional one of 1921. They also draw an interesting comparison between the Jubbulpore saurians and the Mæstrichtian saurians of South America, and I hear that the examination of the bones collected by Matley two years ago is likely to fix finally the age of the Jubbulpore Lametas as Mæstrichtian.

In 1934 Prof. B. Sahni assisted by Messrs. Srivastava and Rao described the silicified flora of the Deccan Intertrappean beds including a number

of seeds and pieces of wood collected partly by Prof. Sahni, partly by Mr. Rode, and partly by myself. Later he published an article in *Current Science* in which he stated that the flora of the inter-trappean beds was comparable to that of the London clays. Dr. Fox replied to this pointing out the strength of the evidence educed by Blanford, and doubting whether the evidence of fossil plants could be considered as good as the field evidence. Accordingly he favoured the retention of the Nagpur Traps in the Cretaceous.

In 1935 K. P. Rode published an interesting account of a fossil wood and breccia zone between the Bagh beds and the Trap in the Deola-Chirakhan area, conclusive proof of the unconformity between these two series of rocks.

Finally in the present year Messrs. L. Rama Rao, S. R. Narayan Rau, and K. Sripada Rau have collected numerous foraminifera and species of *Chara* from the infra- and inter-trappean beds of Rajahmundry. The foraminifera, like the other marine shells, might be either Upper Cretaceous or Tertiary. Some species of *Chara* from the Intertrappeans are, however, said to be definitely Tertiary by Dr. Julius Pia of Vienna. In this year also my work on the Trap rocks in the Satpura region became available. This was more concerned with other aspects of the Trap than with its age, but a few scraps of information bearing on that subject were collected. The close relationship of the Lametas to the Trap was noted, a fact which seems to be proved by the occasional occurrence in them of volcanic ash. Part of a fossil palm stem was picked up on the site of a Lameta outcrop, and was believed to be of Lameta age. Intertrappeans were noted in a number of areas. In these occur the usual gastropods and lamellibranchs, insect remains, cypridæ, fish, and plant remains. The most interesting of these are the fish remains which according to Dr. S. L. Hora include scales of two different types of fishes. Dr. Hora wrote as follows : 'The scales are of two types, (i) an imperfect impression of a scale similar to that of Woodwards' *Eoserranus hislopi*, and (ii) several well preserved much smaller scales of either a Nandid or an Anabantid fish. These families are represented by several genera at the present day ; the fishes are usually found in pools, ditches, and marshes, and are tenaceous of life '. All the fossil remains had a modern appearance. Many of them had histories extending back into the Cretaceous, but all of them might be said to be more typical of Tertiary than of Cretaceous deposits.

Up till recently the determination of the age of any rocks has depended on the field and fossil evidence. Within the last few years it has, however, become possible to get an idea of a rock's age from its lead-uranium-helium ratios, and from its radium content. Work on the Trap is proceeding on these lines, but very few results have yet been published. An estimate of the age of the basalt and felsite of the Pavagad hill has been made by Dubey on the basis of the heliumlead ratio. The basalt proved to be Eocene and the felsite Miocene. I mention these results as I think them interesting, but I consider they require checking by other radioactive methods before they can be accepted as reliable.

Summing up we see that the pioneers, basing their opinion on the fossil evidence, considered the age of the Trap to be lower Tertiary, probably the same age as the London clay. Writers of the middle period, scorning the evidence of the fresh water fossils, and basing their opinions largely on the field evidence, considered the age of the Trap to be late Cretaceous possibly extending into the Tertiary. Finally recent writers supported by the most up to date fossil researches and by a few measurements of the helium-lead ratio have returned to the ideas of the pioneers.

The question for discussion seems to me whether the field evidence outweighs in value the other evidence.

The fossil evidence is undoubtedly strong. Some of the species of *Chara* are said to be definitely Tertiary, the fossil plants are closely allied to the Tertiary flora of the London clay, the fish are said to be Tertiary,

the Cypridæ according to a recent letter from Prof. Bonnema are more likely to be Tertiary than Cretaceous, and the same probably applies to the gastropods and the lamellibranchs. The insects, tortoises and frogs have not yet been sufficiently studied to be of much use in fixing an exact horizon, but they certainly cannot be cited as an argument against the Tertiary age of the Deccan Trap.

Thus six different lines of approach all lead to the same conclusion, namely that the fossils in each line might just possibly be late Cretaceous but are more likely to be Eocene. I consider this to be almost conclusive evidence of an Eocene age for the Intertrappeans. The only way of avoiding this conclusion is to declare that the flora and fauna of India at this period were in advance of those in other parts of the world. If this unlikely proposition were true it should be possible to show that this advanced animal life has migrated from India to other countries at a later date. Perhaps the palæontologists may have views on this aspect of our subject.

With the field evidence is bound up the fossil evidence derived from the rocks immediately overlying and underlying the Trap. The regions of maximum importance are Surat, Bagh, and Jubbulpore. Rajahmundry and Sind are hundreds of miles from the main body of the Trap and are therefore less important.

Surat is the keystone of Blanford's argument. Apparently the Trap there abuts on the Nummulitics, and must have been slightly moved from the horizontal before the deposition of those beds, for an Intertrappean bed can be followed for miles in the Trap scarp till it is finally lost below the marine sedimentaries. The marine rocks are also full of Trap debris. There is, no doubt, an unconformity, but is it necessarily as big as Blanford makes it out to be. The Trap flows here, as elsewhere, are sub-aerial. Any little marine incursion coming up against their margin would soon erode a scarp like that at Surat and the sediments laid down in a gulf of this kind would naturally be crammed with Trap debris. I see no real reason to think that the unconformity here is greater than that at Bagh. Blanford talks of the Trap flows at Surat as if they were the uppermost flows of the whole series, but he gives no evidence of any kind that this was the case. Supposing that they are in reality the basal flows, and the presence in them of an Intertrappean bed rather favours this interpretation, a small unconformity between them and the Parisian Nummulitics would certainly not prevent them being Tertiary.

At Bagh everyone is agreed that there is a distinct unconformity between the uppermost Bagh beds and the Trap, and if we can accept Bose's view that the uppermost Baghs are the equivalent of the Ariyalurs or uppermost Cretaceous of Madras, then there can be no possible objection to the Trap flows being Tertiary.

At Jubbulpore the Traps overlie the Lametas. Now the Lametas are a very peculiar formation. They are in most cases only a few feet thick, and they vary greatly from place to place. Sometimes they abound in red clays or marls, sometimes they are markedly conglomeratic, sometimes they certainly contain volcanic ash. In most cases the chief difference between them and the underlying beds is that they are very calcareous. The explanation of the lime is almost certainly that it has been deposited after the formation of the beds by waters coming from the overlying Trap flows. Had it not been for this secondary deposition of lime I think we would have all considered most of these rocks to be the ancient soil cap of the land in the period preceding the great outpouring of lava, and I certainly regard them as an altered soil cap in most cases.

Now in a land area there are always lakes and river beds in which fresh water sediments are deposited. I consider that the deposits so ably described by Matley near Jubbulpore are lacustrine or riverine deposits of this nature. As far as I can see there is no reason why such deposits might not contain fresh water fossils of any age or even of several ages. That they do not happen to contain any fossils which we can definitely

say belong to the uppermost Cretaceous or Tertiary has in my opinion very little bearing on the age of the Trap.

The Rajahmundry basalt flows are hundreds of miles from the nearest outcrop of undoubted Deccan Trap, further in fact than the Jurassic Traps of Rajmahal are from the nearest Deccan Trap outliers. It would be perfectly legitimate to ignore them entirely. But it is not necessary to do so. Das Gupta's discovery of *Cardita beaumonti* in the infra-trappeans there fixes their age as uppermost Cretaceous. As there is an unconformity between them and the Trap the latter is placed as Tertiary.

Before leaving Calcutta I examined the maps and specimens of Trap from the Bor hill in western Sind, where a Trap flow occurs between the *Cardita beaumonti* beds and the Ranikot. Both the mapping and the specimen show this to be a fact, but the supposed Trap bed found 700 feet below the *Cardita beaumonti* beds at the same place only occurs in one small area, and looks more like an intrusion than a flow. The specimen from this supposed flow is quite white and contains numerous so-called calcite amygdales. Looked at under the microscope it is mainly composed of felspar and greatly resembles an acid differentiate of the Deccan Trap. Rocks of this type are fairly common, but so far as I know are always intrusive. The so-called calcite amygdales clearly show signs of reaction with the rest of the rock. This would not be the case in a true calcite amygdale which is essentially a steam cavity left in the solid basalt and filled with calcite long after the consolidation of the rock. I think the supposed amygdales in this rock are pieces of calcite picked up by the liquid magma in passing through some adjacent calcite bed. At all events I do not accept this rock as a true Deccan Trap flow without further investigation in the field.

The main flow at the Bor hill overlies marine sediments and underlies fresh water ones. Nobody has suggested that it is anything but an ordinary sub-aerial flow. It seems therefore as if there must be a slight unconformity between the marine beds and the flow. Probably the latter may be looked upon as the basal bed of the Ranikot stage, that is Tertiary.

It is a very remarkable thing that flows of Trap should overlie the *Cardita beaumonti* beds at places so far apart as Sind and Rajahmundry. It shows that volcanic activity burst forth in a number of widely separated areas at about the same time. It seems to me that the zenith of the Deccan Trap vulcanism probably occurred early in this great series of lava floods, for vulcanism tends to wane towards the close of a volcanic cycle. I therefore regard these flows of Sind and Madras as the equivalent of some of the flows in the Central Provinces and quite possibly of the lowest of these.

I conclude therefore that the field evidence is not decisive enough to negative the views of the pioneer geologists, supported as they are by recent palæontological research and by results based on the helium-lead ratio of the basalts. In my opinion the earliest Deccan Trap flows ushered in the Eocene period in India. There is no reliable evidence as to how long the vulcanism lasted, but from the general resemblance of the fossils in the uppermost intertrappean beds at Bombay to those in the Central Provinces I think it probable that all the Trap flows are Eocene.

B. SAHNI (*Lucknow*).—As one who first reopened this question in India three years ago (*Sahni, 1934*) I gladly welcome the opportunity of taking part in this discussion and desire, at the outset, to thank the several members of the Geological Survey who have so generously helped me with information and material.

(*a*) *Historical.*—Viewed in its historical setting the question of the age of the Deccan Trap affords a useful instance of the way in which the evidence of fossil plants, until recent years regarded with scepticism by Indian geologists, has at last been vindicated. In Hislop's time the flora of the Intertrappean beds was regarded as of Tertiary age (*Hislop, 1853, pp. 58–76 ; Hislop, 1853 a, pp. 148–150 ; Hislop and Hunter, 1855,*

p. 345 ; Carter, 1857, p. 247 ; also *T. Oldham, 1871, p. 77*), and compared with that of the London Clay, which Bowerbank (*1840*) had described only a few years previously. It is noteworthy that almost the whole of this material came from the Nagpur-Chhindwara region where, according to the Geological Survey, the lowest part of the series is exposed and is frequently seen resting unconformably upon the Archæan rocks. Subsequently the plant collections became scattered and for over half a century were apparently lost to science, while a bitter controversy over the age of the Gondwana flora resulted in a serious lack of confidence in the stratigraphical value of fossil plants. In 1884 the eminent British geologist W. T. Blanford, who will always be respected for his balanced views on most debated questions, was led to remark (*Blanford, 1885, p. 50*) that if the testimony of fossil plants were to be relied upon we would have in India ' a Rhaetic flora overlying a Jurassic flora and a Triassic fauna above both ', and in Australia ' a Jurassic flora associated with a Carboniferous marine fauna '. On a variety of indirect evidence which we need not repeat here, Blanford (*1867*) gave the stamp of his great authority to the idea that the Deccan lavas were poured out during the Cretaceous period. In the second edition of the Manual of the Geology of India (*R. D. Oldham, 1893*), where the whole question was discussed in detail, the conclusion arrived at was distinctly cautious and non-committal. In 1908 Sir A. Smith Woodward found indirect evidence in support of a Tertiary age. But ultimately Blanford's view of an Upper Cretaceous age was adopted as the official view of the Geological Survey (*Holland, 1926, pp. 64, 88*) ; and it has figured on numerous occasions as a conclusion generally accepted by geologists both in India and abroad.[1]

The writer himself freely accepted this view until, towards the end of 1933 (after a comprehensive review of the palæobotanical evidence, the only *direct* evidence which seemed to lead to any definite conclusions) he expressed his accord with the old opinion of Malcolmson (*1837*), Hislop and Hunter (*1853*), and T. Oldham (*1871*) that the traps were of early Tertiary age (see *postscript in Sahni, Srivastava and Rao, 1934, p. 27*). It is significant, as stated above, that Hislop and Hunter had compared the Deccan flora with that of the London Clay. There was no question, in those early days, of any detailed comparison of the plant remains. Even now a serious difficulty in comparing the Deccan flora with others lies in the fact that this flora is silicified while most other floras of late Mesozoic or early Tertiary age are only known from impressions. The most important exception is the London Clay flora, recently described in great detail by Mrs. Reid and Miss Chandler (*1933*). It is with this flora that the plant remains from the Deccan, when fully described, will probably be found to show the clearest affinities.

(*b*) *Palæobotanical evidence.*—The detailed description of the Deccan flora, which I have recently brought together from several scattered museums in India and abroad, and to which considerable fresh collections have been added by the Indian Geological Survey, by Rode, Parija, Agharkar, Shukla and the author, will take several years. But from a preliminary survey of the material accumulated at Lucknow it already seemed clear to the writer in November 1933 that, considered as a whole, the flora has a decided Tertiary aspect. Briefly, the evidence (*Sahni, Srivastava and Rao, 1934 ; Sahni, 1934*) is as follows :—

1. Among the Angiospermous remains so far collected there is a strikingly large proportion of Palms, such as is unknown in any Cretaceous flora. From all available records it appears that this family of plants first arose in the Cretaceous but that it did not become an important group till the Oligocene and Miocene (see *Schenk, 1888, pp. 204-205 ;*

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[1] Not long ago, under the influence of Matley's work on the geology of Jubbulpore, there was even a tendency to push the traps down into the Middle Cretaceous.

Schenk, 1890, pp. 371-372, Drude, 1889, pp. 90–93; Lesquereux, 1878, pp. 109-110, 348-349).

2. Among the palm fruits there is a very characteristic Eocene genus, *Nipadites* (or *Nipa*). This was first recorded by Hislop in 1853 (*l.c., p. 68*; see also *Carter, 1857, pp. 264, 718*). Although Hislop's type specimen is now lost, a fresh specimen (*N. hindi*) recently discovered by Rode (*1933, pp. 171-172*) leaves no doubt of the occurrence of this important genus in the flora. Nearly all the fossil records of *Nipadites* are Eocene.

3. There is a species of *Azolla* (*A. intertrappea*, Sahni and Rao), a living genus of water-ferns, all the previous records of which, in fact of the Hydroterideæ as a whole, are either Tertiary or Pleistocene (see *H. S. Rao, 1935, pp. 192–194*).

4. The abundant remains of Charophyta, already recorded by Malcolmson (*1837*) a hundred years ago, and later by Hislop and Hunter, have not yet been described in detail, but recently Messrs. S. R. Narayan Rao and K. Sripada Rao (*Rao and Rao, 1935, p. 324*; see also *Rao, Rao and Rao, 1936, pp. 160-161*) have discovered in the Rajahmundry area several forms of '*Chara*' (*Gyrogonites*) which they tentatively identify with known Tertiary species. Certainly the most plentiful records of this genus are from the Tertiary and later rocks. Of a total of 70 species on record, according to Pia (in *Hirmer, 1926, pp. 88-89*) as many as 61 are of Palæocene to Pleistocene age. In addition to these Charophyte fossils these authors mention the discovery of *Acicularia*, an essentially Tertiary genus of algæ. It is stated that the traps in the Rajahmundry area, like those of Nagpur-Chhindwara, belong to the base of the series (*Rao, Rao and Rao, 1936, p. 164*).

Of all the above arguments for a Tertiary age I am inclined to attach the greatest value to the general character of the flora, for after all the individual species are mostly new and therefore stratigraphically of no great importance by themselves. Considered as a whole the palæobotanical evidence is distinctly in favour of a Tertiary age.

(*c*) *Animal evidence.*—It is not for a palæobotanist to speak of the animal remains, but one must guard against the danger of an uncritical acceptance of such species as *Physa* (*Bullinus*) *Prinsepii* and even *Cardita Beaumonti* as fossils characteristic of the Upper Cretaceous; for it must be remembered that both these when first described from India were new to science. They were not species identical with fossils from a known horizon in the standard scale. The same remark must, of course, be applied to all the new species in the flora as well as in the fauna, and their age value must be similarly discounted. But even after this has been done there remains a large body of evidence, relating to the general composition of the flora, which points definitely to a Tertiary age. Unfortunately most of the animal remains from the Intertrappean series belong to genera having long ranges in geological time. Some ostracod remains from Deothan which Mr. Crookshank kindly sent me in the belief that they were seeds, as well as some old specimens from the Hislop and Hunter collection in the British Museum, were kindly examined at my request by Prof. J. H. Bonnema of Groningen, and his opinion (communicated in a letter dated 10-10-1936) was that although their evidence was not decisive, they were more probably Tertiary than Cretaceous. Among the same specimens I identified some fish scales with those of *Eoserranus Hislopi* A.S.W., an identification afterwards confirmed independently by Dr. S. L. Hora of Calcutta.[1] Sir A. Smith Woodward regards this fish as having Eocene affinities. It was first described by him from beds at Dongargaon (*1908*) which were supposed to be Lametas, but which later Matley (*1921*) contended were Intertrappean. If the Dongargaon beds were really Lametas, as originally thought, the evidence

[1] Since the above was written Dr. Hora has considerably elaborated the evidence of the Intertrappean fish fauna in favour of a Tertiary age, in a paper to be published in the Records of the Geological Survey of India.

of their fish remains for a Tertiary age for the overlying Intertrappean beds would gain force, even if Matley's view of a conformable passage into the Intertrappean series is correct.

(*d*) *Field evidence.*—I must refrain from touching upon the evidence concerning the field relations of the Deccan Traps with the associated strata, because the problem of dealing with igneous rocks scattered over such a large area is by no means so simple as that of a series of sedimentary beds superposed in an orderly sequence. The possibility has also to be considered that the igneous activity in different parts of the peninsula may have been spread over a period extending from the late Cretaceous far into the Tertiary. These considerations have, of course, not been overlooked by others who have discussed the question (*Fox, 1935* ; *L. Rama Rao, 1936*). But, as stated above, the whole of the palæobotanical evidence is derived from the regions round Nagpur, Chhindwara and Rajahmundry where, according to Fermor and others, the lowest portion of the series is represented.

(*e*) *Evidence from Radioactivity.*—Dr. V. S. Dubey of Benares states that his work on helium ratios, carried out on some of the rocks in Western India, gives a Lower Tertiary age to the basalts. This would indicate that the basalts round Nagpur and Chhindwara are of a somewhat older date. But whether the latter were so much older as to reach back into the Cretaceous period can only be decided by investigating the helium ratios of samples taken from this area. It is much to be hoped that Dr. Dubey will turn his attention to this critical area and help to solve a problem of interest alike to the petrologist and palæobotanist.

(*f*) *Conclusion.*—Taking the evidence as a whole the balance is decidedly in favour of the original view, now just a hundred years old, that the earliest of the Deccan lavas were poured out after the dawn of the Tertiary era and not during the latter part of the Mesozoic. It is gratifying for the palæobotanists to see members of the Geological Survey now coming forward to support this view. The question as to the total duration of the igneous activity can only be decided after further evidence is available, especially from the Bombay area where the fossiliferous beds are several thousand feet higher than those round Nagpur.

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S. L. HORA (*Calcutta*) remarked that he received from Mr. Crookshank two lots of fossil fish-remains. Scales or impressions of scales are well represented in this material and are sufficiently distinctive for generic determination.

The first lot comprises, as already mentioned by Mr. Crookshank, remains of *Eoserranus hislopi* and of Anabantoid or Nandid fishes. The second lot consists mostly of Percoid and Cyprinoid scales of the Rasborinæ type. It is well known that the present-day Teleostean fishes were evolved in the interval between the close of the Cretaceous and the beginning of the Eocene and the occurrence in the Traps of forms very closely allied to the living forms lends considerable support to the Tertiary age of these lava flows.

Dr. HORA also referred to the probable cause of the similarity between the freshwater faunas of Europe and India. He stated that his researches on the origin and distribution of the freshwater fish-fauna of south-eastern Asia (the results of these investigations have not yet been published) in the light of palæo-hydrographical information that has become available during the last decade or two have conclusively shown that this fauna originated in the South Chinese and Indo-Chinese regions and spread westwards, a branch going towards the north to Southern Europe while another branch travelled towards Siam, the Malay-Peninsula, India and Africa. The similarity of the south-eastern Asiatic forms and the European forms is thus due to their common origin and not to any exchange of faunas *inter se*.

L. RAMA RAO (*Bangalore*).—Of all the problems connected with the Deccan trap, that regarding the age of this formation is perhaps the most important. Several papers dealing with this rather controversial problem have been recently published, and it is evident that we have now to reconsider our position and see how far the prevailing view that the Deccan trap belongs wholly or almost wholly to the Upper Cretaceous is still tenable. In this connection it is useful to remember that the Deccan trap of India is only one of several other similar fissure eruptions occurring in various other parts of the earth at about the same period of time. This will enable us to take a wider outlook and realize their kinship with similar geological problems elsewhere.

For determining the age of a rock formation like the Deccan trap, we have to rely on three kinds of evidence : (*a*) the age of the beds below the traps or the *infra*-trappeans, (*b*) the age of the sedimentary beds within the traps or the *inter*-trappeans, and (*c*) the age of the beds above the traps or the *supra*-trappeans. In any given area where we have one or more of these evidences, the most important point to note is the exact position which the traps of that area occupy in relation to the main mass of the formation ; and at the same time, while comparing the evidence in different areas, we must also realize that all the infra-trappean beds—as also the supra-trappeans, if any—of different areas need not necessarily be of the same age.

From this point of view and in the light of recent palæontological discoveries in the inter-trappean beds of the Nagpur-Chhindwara and

Rajahmundry areas, the problem of the age of the Deccan trap has been discussed in a paper recently published by the author (*Proc. Ind. Acad. Sci.*, Vol. IV, No. 3—Sept., 1936) in which an attempt has been made to offer a new interpretation of their mode of accumulation and geological history, according to which it would appear that the Deccan trap eruptions began at the close of the Cretaceous period and continued not only throughout the Eocene but probably extended even into later periods.

C. S. Fox (*Calcutta*).—In the Indian Peninsula there are two groups of basaltic lavas—the Deccan traps and the Rajmahal traps—which are petrologically identical, but which on fossil evidence have been placed at the close of the Cretaceous and at the base of the Oolite respectively. It was the official view that the Deccan traps were poured out at the close of the Mesozoic era rather than at the dawn of the Eocene period. During the past few years evidence has accumulated to suggest a basal Eocene age for the Deccan trap lavas, but this evidence is largely dependent on the value of fossil plants as indicators of geological horizons. The age of the Rajmahal traps was fixed indirectly.

On the Madras coast there are Upper Gondwana strata with a Rajmahal flora, but including some marine fossils which were determined as Jurassic cephalopoda. Recently these supposed Jurassic animal remains were re-examined by Dr. Spath who considers their previous identification an error. In his opinion the fossils appear to belong to the uppermost Jurassic or perhaps the lowest part of the Cretaceous. Thus the age of the Rajmahal traps would be immediately lifted to about that of the Umia beds of Cutch and belong to the Lower Cretaceous period. Such a correlation has already revived an opinion that the Rajmahal and Deccan traps belong to the same volcanic period—with the Rajmahal outflows as the earliest phase of the eruptions. Such an idea is comparable to the Panjal traps of the Kashmir Himalaya, where the lavas appear to have been erupted at intervals through a considerable range of time.

From recent surveys in the Assam range it would appear certain that the Sylhet traps are definitely of pre-Eocene age as they never cut the Tertiary formations and underlie strata with Upper Cretaceous marine fossils. Petrologically the basaltic and dolerite dykes met with in the Khasi and especially in the Garo Hills of Assam are identical with the Rajmahal and Deccan traps. It is thus known on the evidence of a marine fossil fauna of a reliable type that the Sylhet trap is pre-Upper Cretaceous.

In Afghanistan the Doab volcanic series are intrusive in marine strata of Upper Triassic age, but have not been found in the Oolitic plant beds of the Saighan series, while the trap intrusions south of Kabul are intrusive in Upper Cretaceous strata.

In Abyssinia the traps of Ashangi and Magdala, which have been thought of as the westward representatives of the Deccan trap, were completely isolated, and their lavas appear never to have covered Somaliland and certainly did not extend into Arabia or the Arabian Sea. The oldest of the Abyssinian lavas is not older than Upper Cretaceous and was possibly poured out early in Eocene times. The younger traps, judging by fossil wood from inter-trappean beds, is probably of Miocene age.

The problem of the Panjal traps seems to be similar to that of the Deccan traps—each being in a separate but adjacent region. Volcanic activity has clearly been irregular—beginning in the Himalayan geosyncline in Upper Palæozoic times and continuing in the same belt up to Upper Triassic times. Then beginning afresh in the Assam area in Cretaceous times, and bursting forth subsequently in the Peninsula in early Eocene times, while eruptions also occurred at the same period in Afghanistan and Abyssinia as separate outbreaks, until, finally, after eruptions in Abyssinia in the Miocene period, there came a cessation when the Himalayas appeared as a mountain chain.

The older eruptions of the Panjal traps and the Doab series were probably marine in origin, while those of Sylhet, Rajmahal, the Deccan and Abyssinia were clearly subaerial. The upper lavas of the Deccan trap and lower lavas of Abyssinia are curious types and suggest changes in the basaltic magma below—as though mixing with acid material, and occasionally with very basic lavas, had taken place prior to eruption. On the whole the evidence suggests separate phases of eruptions and not a volcanic series. It seems best, therefore, to keep the Rajmahal traps quite distinct from those of the Deccan, and those of the Pir Panjal from the Doab series, nor should those of Ashangi be correlated with the traps of Magdala.

V. S. DUBEY (*Benares*).—The author has been connected with the study of the Deccan traps in Western India at Cutch, Kathiawar, Gujerat and the western coast of India, up to 80 miles south of Bombay. He has analysed more than seventy rocks and determined their petrographic characters. He has also examined the radio-active content of some of these rocks together with their helium content. The work could not be published till now due to lack of time.

The conclusions based upon this study are :—

I. The Deccan traps proper can be divided definitely into three divisions and perhaps into four :

1. Plateau basalts : these turn more and more alkaline till they become highly alkaline at the end.
2. Ultrabasic rocks : these occur in the form of olivine gabbro, oceanite, picrite, limburgite, peridotite, etc.
3. Acid rocks : these comprise granites, granophyres, rhyolites, trachytes, pitchstones, obsidians, etc.
4. Basalts ?

In Central India and the Central Provinces the rocks are of a plateau basaltic nature, while the rocks towards Kathiawar and of the higher flows and the dykes show a higher alkali content. The alkali rises from 2·40 to 8·71. Silica becomes slightly lower by two to three per cent. with the consequent reduction in the amount of ferromagnesian minerals and increasing preponderance of alkaline felspars.

There is no evidence in Kathiawar to show that this activity lasted for a very long time at any one spot. The age may be anything up to Lower Eocene.

The ultrabasic rocks occur in dykes and small masses. The field evidence does not show a very large interval between the Deccan trap and these rocks. They occur right from Cutch up to several miles south of Bombay along the coast line, in all three phases—volcanic, plutonic and hypabasal. Their affinity is with the ultrabasic rocks of Baluchistan.

The acid rocks are much more extensive than the ultrabasic ones. They are also distributed along the whole coast. In Cutch they have not been noticed. There appears a vast time interval between these acid intrusions and the plateau basalts. Sufficient period had elapsed in which denudation of at least 2,000 ft. of basalt had taken place and the topography very much like the present was established. Probably they have got affinity with the Middle Tertiary acid rocks of Baluchistan and the Himalayas.

II. The author has recently come to the opinion that the Malabar hill basalts of Bombay are later than even the acid rocks. The dykes of these basalts cut the acid rocks. The Malabar basalts, therefore, belong to a more recent age contemporaneous with the recent volcanic rocks of Burma and Baluchistan. It is possible that their origin is connected with the great linear fault of the Bombay coast. In reality both kinds of basalts exist in Bombay, one of the early Tertiaries and the other of the late Tertiaries and divided by a vast interval of time. One more notable fact with regard to these late basaltic rocks of Bombay, is that they are poorer in alkali as compared to the rocks of the last phases of the Deccan

traps. These kinds of rocks besides differing in chemical composition also differ in their radio-active contents. The basaltic rocks showing about 0·5, the ultrabasic rocks about 0·2, while the acid rocks about 2·5.

III. The chemical and radio-active study suggests that all the three are not differentiates from the same magma, but show an independent origin. It is very probable that they were derived from the three zones of the earth's crust—acidic, basaltic and ultrabasic.

IV. The work on helium ratios carried out by the author with a few of the rocks gives a Lower Tertiary age to the basalts.

The PRESIDENT, in closing the discussion, said that he thought that the purpose of having this discussion had been amply fulfilled. There could be little doubt, now, that the age of at least the greater part of the Deccan Trap must be assigned to the early Tertiary. He was less confident about taking the upper limits as high as Dr. Dubey wished. The latter's conclusions were based partly on the field evidence, but so far no adequate account of this had been published. In conclusion he suggested that members of the Section should try and visit some of the localities, such as at Surat and in Sind, where the stratigraphical evidence was still in some doubt.

II. NUTRITION IN RELATION TO HUMAN BEINGS, FARM LIVE-STOCK AND CROPS.

Section of Medical and Veterinary Research.

COL. A. OLVER, President of the Section, in the chair.

A. OLVER (*Delhi*).—I may refer to my Presidential Address to the Medical and Veterinary Research Section, in which I have already dealt with this subject. In addition to its broad scientific interest the matter is of the greatest practical importance and urgency and it is the one above all others which H.E. the Viceroy has most at heart, viz. the better nutrition of the masses. The practical aspect must therefore always be kept in the fore front.

To the poor peasant an adequate diet was a matter of pice and annas, and to the cultivator, of small capital, costly model buildings and expensive processes meant nothing.

On the other hand there was ample evidence that if suitably assisted in their villages to dispose satisfactorily of their produce, whether from crops or animals, Indian ryots were not slow to find means of taking advantage of such an opportunity of improving their position. My view more than ever after years of careful study of the subject is that the solution of this problem must lie in the development of a well-balanced system of mixed farming in India. In developing such a system it is clear that the greatest possible use should be made of all the resources of modern science, in order to secure, under the very varying conditions of soil and climate which exist, the maximum return from the cultivable land available.

In this the provision of better and more remunerative cattle must play an important part and I believe that fodder crops and cultivated grasses should take a much more important place than hitherto. More should no doubt be done to improve and make better use of village and forest grazing, but the tendency at present is to rely too much on free grazing for the maintenance of stock. To produce more money for himself and a better diet for the people, within the reach of the masses, it would be in their best interest and that of India if, as far as possible, every cultivator would keep and maintain properly, mainly on fodder crops grown on his land, at least one good cow. He could thus produce more and better milk, more manure, and better work animals.

He felt that free grazing, out of which so much political capital had been made, must to a large extent be a Will-O-the-Wisp in a country where the pressure on the land was so great. He quoted figures from the report of a special commission of forest officers, which, with specially selected Animal Husbandry and Agricultural Officers, had sat recently in Madras to show that forest grazing could never be an important factor in dealing with this problem, while, with better care and management, village grazing lands might be much improved.

Finally he mentioned a matter which he felt was of considerable practical importance, viz., the fact that since the milk of buffaloes and cows contained approximately equal percentages of the solids-not-fat, mainly protein and minerals, which are essential to a proper diet, buffalo's milk, heavily watered down as it usually was before it reached the consumer, was not of such high nutritive value, particularly for growing children, as was cow's milk with an equal percentage of butter-fat. Cow's milk, being less rich in cream, will not allow of such heavy watering without detection of its protein and mineral content is therefore higher than that of the buffalo milk usually sold.

W. R. Aykroyd (*Coonoor*).—Many of the observations of the research worker on human nutrition were of great importance to the agricultural and animal nutrition worker, and for the guidance of agricultural and food production were policies in the right direction. It was the task of the human nutrition research worker to discover and demonstrate the chief defects of Indian dietaries. This problem could be approached by the study of actual diets consumed by sample groups in towns and villages, and by the investigation of the incidence of food deficiency diseases and various physiological conditions associated with malnutrition. Both these lines of investigation were being followed.

The dietary standards put forward by American and European physiologists such as, for example, the standards recently suggested by an expert commission of the League of Nations, purported to represent the *optimum* and allowed a high margin of safety. Even casual observation at once showed that average Indian diets were deficient when compared with such optimum standards. The nutrition worker in the East might, however, justifiably adopt a lower standard representing a moderately satisfactory diet. But even when he had reduced his demands to a minimum point which might be difficult to justify on scientific grounds, he found that the diets of typical Indian village families were deficient in terms of such minimum standards.

In dietetics 'enough food took precedence over the right sort of food'. Insufficient data had been accumulated about the calorie intake of typical Indian village population groups, but what information existed suggested that large sections of the population might not have enough to eat. Tentative analysis of the amount of food available per consumption unit in the Madras Presidency supported this conclusion. He was inclined to estimate the minimum daily requirements per consumption unit of a South Indian peasant family as about 2,500. If the diet of a peasant or labourer fell below this figure, adjustment occurred as follows: basal metabolism was reduced, the body functioning at a lower level of vitality, and energy output was made consonant with energy intake. In simple terms, the underfed labourer was lethargic, and his output of work small. He reached a kind of dreary adaptation to his environment. But the remarkable capacity of the human body and the human mind to adapt himself to semi-starvation should not influence the nutrition worker in setting up standards of calorie requirements.

If the diet surveys which were to be carried out in various parts of the country showed that there was widespread insufficiency of food, then the first necessity was simply to increase food supply, and this necessity must remain the foundation stone of agricultural policy.

On the qualitative side, typical Indian dietaries showed serious deficiencies. There was a relative lack of animal products such as milk,

eggs and meat, of fish, and also of pulses, vegetables, and fruits. Experiments had shown that the addition of small quantities of skimmed milk to the diet of typical Indian children living on a largely cereal diet, containing no milk or eggs, produce a rapid acceleration of growth and an improvement in general health and vitality. The change which took place brought realisation of the handicaps under which a deficiently fed population labours. It seemed probable that the most serious fault of the average Indian dietetics was their relative lack of one or more of the food factors contained in skimmed milk, proteins of high biological value, vitamin B_2, and assimilable calcium. Probably no food of vegetable origin would supplement average Indian diets as effectively as milk or eggs. Special mention should be made of fish which contained some of the food elements most needed by the poorer classes in India. The fishing industry in India was in a backward state. It was noteworthy that the Japanese, in attempting to improve the diet of the country, had paid great attention to the development of fisheries and had obtained remarkable success in this direction.

Pulses, though rich in vegetable protein, were not of the same nutritive value as milk or eggs. Nevertheless, they contained food factors which were relatively lacking in cereals and particularly in milled coreals. Diet surveys had suggested that the pulse intake of villagers could be increased with advantage, and an adjustment of crops planning so as to increase pulse production might suitably be made a feature of agricultural policy. Dramatic results in the shape of improved nutrition could not, however, be expected to result from such an adjustment. The soya bean did not appear to have any advantage over the common pulses which already formed part of the Indian diet, and it did not seem desirable that a great deal of time and trouble should be spent on stimulating the production and consumption of this legume in India.

The average Indian villager appeared to consume vegetables and fruits in very small quantities. These foods contained elements needed by the population, green leafy vegetables being particularly valuable. Preliminary investigation suggested that there might be a great deal of 'subclinical' scurvy in India. The most important sources of the antiscorbutic vitamin—vitamin C—were fresh fruits and green leafy vegetables.

Red palm oil, derived from the fruit of the West African palm *Elaeis guineensis*, was extremely rich in carotene, the precursor of vitamin A. It was probable that very effective medicinal preparations for the treatment of vitamin A deficiency in human beings could be made with red palm oil as an ingredient, and this oil could be incorporated in the diet in various ways. The plain *Elaeis guineensis* was already grown in Malaya and Burma, and might also be grown in India and produce large quantities of cheap vitamin A for the benefit of the population. Cod liver oil was relatively more expensive. The average Indian diet was deficient in vitamin A, and there was great need for a larger supply of this factor.

While the study of diets actually consumed in India indicated that Indians of the poorer classes consumed an inadequate and ill-balanced diet, another method of approach led to similar conclusions. The clinical examination of groups of school children in towns or villages in South India revealed that a high percentage showed visible symptoms of deficiency diseases, one of the commonest being stomatitis due to vitamin B_2 deficiency. Symptoms were observed in a larger percentage of children of the poorer classes than of children of the more prosperous classes. A point of interest was that a higher incidence of deficiency disease was observed among children of the poorer classes in towns and cities than among poor village children. The probable reason for this was that the poor in the towns consumed milled rice, while the villager consumed millet, or rice in the 'home-pounded' state. The spread of the use of milled rice, while living standards remained at their present level, was definitely to be discouraged.

Further evidence of widespread malnutrition was provided by blood examinations. The hæmoglobin content of the blood of South Indian children was on an average some 20 per cent or more below European standards, and this appeared to be due to an insufficiency of iron in the diet. At present it was difficult to indicate the dietary alterations likely to increase iron intake.

Summarizing, Dr. Aykroyd made suggestions regarding the orientation of agricultural policies, and policy in relation to the production and consumption of food in general, which seemed to be indicated by human nutrition research :—

1. The total food available may be insufficient to meet the quantitative requirements of the population. If this is so, the first and primary need is the production of enough food of whatever kind.
2. The spread of the use of milled rice should be discouraged.
3. The most effective supplements to typical Indian dietaries are animal foods, such as milk, whole or skimmed, eggs and fish. The greater production of milk and eggs may not be immediately possible, and meanwhile the popularisation of imported milk products may be desirable. The question of removing the duty on imported milk deserves serious consideration.
4. Attention should be given to the development of fisheries, now in a very backward state.
5. Pulse production and consumption should be increased. It does not seem desirable to give special attention to the popularisation of the soya bean.
6. Attempts should be made to increase the production of vegetables and fruits, which contain elements needed by the population.
7. Red palm oil is a valuable cheap source of vitamin 'A'. It could probably be produced in India.

B. Viswanath (*Delhi*).—The importance of the condition of the soil with reference to the nutritive value of foodstuffs should be emphasised. Manurial treatment of the soil might have the effect of producing crops with a higher vitamin content. The extractability or solubility of proteins in different solvents varied with manurial treatment. Nitrogenous manuring, while increasing the nitrogen content of crops, depressed their phosphate content; on the other hand, phosphate manuring produced a distinct increase in phosphate content, while at the same time protein nitrogen showed a tendency to rise. The supply of organic manures was therefore a question of considerable importance in India.

Dr. K. C. Sen (*Izatnagar*), and F. Ware (*Muktesar*).—In India the subject of nutrition differed very greatly from the same subject in most other countries of the world in the fact that, while it was necessary to provide sufficient fodder for an enormous population of transport animals, there was no possibility of directly converting these animals into food for the human population at any stage of their existence. The result of this was that to a large extent the human and animal populations of India would always be in competition for the food which can be grown on the available land.

S. L. Bhatia (*Bombay*).—The importance of nutrition in relation to public health should be emphasised. There was abundant evidence that the standard of nutrition in India was very low. Poverty was an important factor in producing malnutrition, but it would also be remembered that diet in India was regulated by custom, tradition and religious sanction which made the task of the reformer and public health worker extremely difficult. Reference should be made to the valuable work of the League of Nations in the field of nutrition. Recent reports of the League, had particularly emphasised the value of the 'protective' foods, viz., meat, eggs, fresh milk, fresh vegetables and

fresh fruit. The speaker drew particular attention to the enormous amount of ill-health in pregnant and nursing mothers, due to improper and incomplete diet, in many parts of India. Pregnant and lactating women needed an abundant supply of good milk. Diet was also of the greatest importance in infancy and early childhood. Here again milk is the crux of the problem.

Efforts should be made to educate the public in dietetics. The scientist had far too long been living a life of proud seclusion. It was high time that the valuable knowledge gained by patient research should be broadcast for the welfare of the people. For progress on a nation-wide scale a concerted effort on the part of the people and the Governments was necessary.

Sir Akbar Hydari said that as a practical administrator, he had learned much during the meeting. The time had come to consider whether a greater proportion of public funds should not be devoted to improving the nutrition of the people, rather than to less vitally important objects.

Mr. Y. D. Wad (*Indore*) discussed the improvement of the quality and quantity of crops by means of enriching the soil. The problem of nutrition seemed to include in its scope the betterment and maintenance of soil condition.

Dr. N. C. Wright, at present touring India to advise on the development of the dairying industry, said that all the speakers had emphasised the high nutritional value of milk and milk products. He stressed the necessity of establishing a better balanced system of agriculture, including a greatly enlarged dairy industry.

Dr. Subrahmanyan (*Bangalore*) discussed problems relating to the quality of foodstuffs.

Dr. K. P. Basu (*Dacca*) referred to the importance of investigating the biological value of proteins.

Colonel Olver in summing up said that the main point which appeared to have been clearly brought out was that a larger proportion of the 'protective' foods of animal origin was essential in order to improve the diet of the people of India. The great importance of an increase in the present consumption of milk had been strongly emphasised by almost every speaker and it seemed clear that far more attention needed to be paid to dairying than had been the case in the past. His own view was that a better balanced system of agriculture was the only feasible way in which a greater and cheaper supply of milk could be secured.

By obtaining the greatest possible return from the land such a system, would enable the ryot to make money from milk or ghee, or provide better food for his family. At the same time it would enable him to produce better working bullocks and more and better farm-yard manure, and would increase the return from crops. An increased and cheaper supply of milk and better work animals could thus be produced on every holding of reasonable extent. The feeling of the meeting had in fact been very clear that in order to provide a satisfactory diet for the people of India it was essential to do everything possible to increase and cheapen the supply of milk and dairy products. They all recognised the absolute necessity for keeping the cost of the diet as low as possible but up to the present it had not been found possible to replace the protective foods of animal origin by the cheaper vegetable foods. Thus sound milk was recognised to be the best and cheapest of all foods but he would like also to mention eggs and poultry as valuable sources of animal protein. More poultry could easily be kept in every village if properly managed and would cost little to maintain since the grain they consumed would otherwise to a large extent be wasted, while there was usually an abundance of the insect life which formed an important part of the diet of poultry.

He mentioned that the value of poultry and poultry products in Great Britain at present exceeded the total value of the wheat crop.

Only by making the greatest possible use of every available source of foods of animal origin, such as milk and eggs, which were of high

dietetic value, could the diet of the people of India be made a satisfactory one, and the most feasible way of providing such foods seemed to be by mixed farming; but more attention should be paid to subsidiary sources such as fish.

III. GLYCOSURIA.

Section of Physiology.

Lt.-Col. S. L. Bhatia, President of the Section, in the chair.

S. A. Rahman opened the discussion and cited some cases of glycosuria which were benefited partly by the regulation of diet and partly by controlling the administration of insulin.

N. M. Basu (*Calcutta*).—Clinically three types of glycosuria are generally met with :—

(i) *Renal glycosuria*, which can be diagnosed by a glucose tolerance test (it shows a normal or slightly depressed curve) and is regarded as harmless.

(ii) *Insulin-sensitive diabetes*, in which the insular organ is diseased and the clinical condition is improved readily by the judicious regulation of diet and insulin administration.

(iii) *Insulin-insensitive diabetes*, in which there is probably an extra-insular preponderance, probably an excess of diabetogenic hormone liberated from the anterior pituitary body and uncontrolled by insulin produced from the islet-tissue; or in which, as has been shown by Himsworth, the factor which renders the body sensitive to insulin, and has been termed insulin-kinase, is deficient, and accordingly the injection of insulin even in high doses has little or no effect on hyperglycosuria.

Curiously enough the latter two forms of diabetes were differentiated almost as accurately as at present and mentioned so long ago as the sixth century B.C. in Sanskrit books.

The characteristics of the insulin-sensitive type are as follows :—

The patient continuously loses weight and becomes thin and weak and restless, although he eats much food and drinks enough water. This type is commoner in the young. On injection of insulin hyperglycosuria is suppressed. The skin of these patients generally becomes rough.

The characteristics of the insulin-insensitive type are as follows :—

The patient is generally corpulent and shows little tendency towards losing flesh. He takes much food, is sedentary and sleeps much. The surface of the skin is soft and oily. It is more common in, though not confined to, the elderly in whom adiposity and hypertony co-exist. As already mentioned, insulin has little effect on the hyperglycosuria.

Ætiology of the disease.—Diabetes has no single cause. In the young it is probably congenital in origin. In adults, although the stages in the development of the disease are not known, the predisposing causes may be set out as follows :—

(i) Obesity or rather the factors which lead to it (Joslin). The various evidence adduced in favour of this pre-disposing factor are :—

- (*a*) Hess produced experimental diabetes in animals by high fat or high fat and high carbohydrate diet.
- (*b*) Himsworth has shown by taking glucose tolerance curves on normal persons living on high fat and low carbohydrate diet, and again on the same individuals habituated to a high carbohydrate and low fat diet, that high fat diet decreases whereas high carbohydrate increase the sugar tolerance.

If the high fat diet be continued for a long time, sugar tolerance is permanently impaired.

Exception.—Eskimos who take a high fat diet, are never found to suffer from diabetes.

(ii) Infection, such as an ordinary cold or a small furuncle, not to speak of severe infections, may disturb sugar metabolism to such an extent that not only may the supply of insulin produced in the body be reduced but also that which is administered hypodermically may be ineffective.

(iii) There is a hereditary predisposition to this disease. It is suggested that the potentiality for this disease is transmitted as a simple Mendelian recessive.

Treatment.—In pre-insulin days the diabetic used to be kept alive by decreasing carbohydrate and increasing fat, the limit being fixed by the necessity of avoiding Ketonuria [the clinical rule to avoid Ketosis being that the fat content of the diet (F) must not exceed the sum of twice the carbohydrate (C) and half the protein (P)—i.e., $F = \text{or} < (2C + \frac{1}{2}P)$].

The high fat diet mentioned above and advocated by Newburgle and Marsh, if continued for a long time, leads to persistent lipæmia and cholesterolæmia, the latter being supposed to be one of the causes of atheroma and as pre-disposing to diatetic gangrene (Joslin does not agree with the above view).

Naturally, therefore, the diabetic specialists gradually adopted a more rational diet containing a normal amount of carbohydrate with the necessary insulin to control hyperglycæmia.

Three outstanding schools which held this view and performed numerous experiments thereon are those of Porges and Adlersberg in Vienna, of Sansum in California and of Rabinowitch in Montreal.

Porges and Adlersberg noticed that sugar tolerance curves in normal subjects kept on a high fat and low carbohydrate diet showed higher peaks and more delayed returns to normal than when they were on a mixed diet. Further, recognising the fact that there is an antagonism between fat deposition and glycogen deposition in liver, they concluded that high fat and low carbohydrate diet can never bring about in a diabetic a return to normal conditions which include storage of sugar as glycogen in liver. Accordingly they recommended the use of as little fat as possible in the diet of a diabetic—50 grams of fat in a diet of 3,000 cal. The amount of protein being normal the caloric is, therefore, provided mainly by the carbohydrate. Increased insulin is found to be necessary at the beginning, but tolerance for carbohydrates gradually increases and less insulin is required later on.

Robinowitch has utilised his clinical experience of the apparent benefit of slight under-nutrition in planning a diet for diabetes. The diet he advocates is low in fat (50 grams), normal in protein (75 to 80 grams) and relatively high in carbohydrate. Such a diet lessens the need for insulin and may even abolish it. He lays particular stress on a low caloric diet.

Sansum recommends a diet of carbohydrate to fat ratio of 3 or 4 to 1 with adequate caloric requirements to maintain normal weight.

Himsworth denies that the increased carbohydrate diet is beneficial in all cases although he admits that the majority are benefited by it. He accordingly suggests that the differentiation of diabetes into insulin-sensitive and insulin-insensitive types by means of insulin-glucose test may prove to be of considerable practical importance as offering a means by which the appropriate diet can be chosen for the particular case. In insulin-insensitive cases increase of carbohydrate in the diet leads to an increase in hyperglycosuria which cannot be easily controlled by insulin.

Incidence of the disease in India.—Although no statistics have been taken of the diet of those suffering from diabetes in their pre-diabetic days, yet there are certain facts which throw a partial light on this question. These are :—

(i) Diabetes is practically unknown amongst labourers and peasants who take a very large amount of carbohydrate, with practically no fat or oil, as they are costly.

(ii) The disease is widely prevalent amongst rich men and earning members in upper middle class families. As a rule, they take rich food (i.e., food containing a large amount of fat or oil) and do not regularly take any physical exercise.

(iii) There are also cases in which it is found that before diabetes sets in, the patients were taking a high carbohydrate diet, with a normal or limited amount of fat or oil, but almost without any physical exercise.

These patients are undoubtedly benefited by a restriction in both carbohydrate and fat intake attended by regular physical exercise.

It is thus obvious from the above that

(*a*) a high carbohydrate and low fat diet with sufficient exercise does not lead to diabetes ;

(*b*) a high fat diet without exercise is conducive to diabetes ;

(*c*) a high carbohydrate diet with a normal or restricted amount of fat but without exercise also leads to diabetes. It is, therefore, to be concluded that lack of physical exercise plays an important part in the incidence of diabetes. It is recognised also that physical exercise diminishes the insulin requirement of the body for controlling the carbohydrate metabolism. It is quite likely that physical exercise is concerned with the production of insulin-kinase in the body, which is believed to sensitise insulin.

It would be advisable in the present state of our knowledge to ascertain the following in order that we may come to grips with this rapidly increasing disease :—

(i) Statistics of the incidence of diabetes amongst various classes of people should be taken.

(ii) Enquiries should be made about the usual diet and daily habits of patients before they were afflicted with the disease.

(iii) The results of the alterations of the diet of diabetes patients in the light of modern knowledge on the course of the disease should be recorded.

If the enquiries suggested above be made, it would be possible for the medical profession to warn the people about the various habits, dietetic and otherwise, which lead to diabetes, and further to plan suitable diets for different types of diabetes to combat the course of the disease, as daily injections of insulin would be always avoided by the people even if they could afford to pay for them.

LT.-COL. S. L. BHATIA (*Bombay*).—Glycosuria is a subject in the investigation of which a close co-operation between the physiologist and the practising physician is most desirable. In no other subject is the need for such team-work more obvious than in this. I have been particularly interested in it for some years. I shall confine my remarks to the chronic and mild type of glycosuria (Diabetes Mellitus) so commonly met with in the middle-aged and the old in this country. I invite your attention to its *prevention* rather than its *cure*. Let me say at the outset that there are three factors responsible for its enormous prevalence here :—

1. *Rich carbohydrate diet.*
2. *Obesity* and sedentary habits.
3. *Mental strain.*

I call these the *Diabetic Triad.* There is strong experimental evidence in favour of these etiological factors.

1. *Rich Carbohydrate Diet.*

(*a*) Homans, Allen, and Bowie have demonstrated definite histological changes (hydropic degeneration) in the granules of the β cells of the

Islets of Langerhans, when food rich in carbohydrates is taken. The technique employed is this. The pancreas is completely extirpated, except that a small graft is transplanted into the abdominal wall without disturbing its blood or nerve supply. It is found that this graft is put to a great strain, when rich carbohydrate food is given to the animal. It shows definite histological changes of the nature of hydropic degeneration in the β cells. It is further observed that these changes do not occur when these animals are treated with insulin; that they are much less marked if the diet does not contain excess of carbohydrates; and that if insulin be given to an animal in whom hydropic degeneration has already occurred, this may disappear, and the cells may revert to their normal condition. This shows that the hydropic degeneration in β cells is associated with their insulin secreting function.

(*b*) In 1925, Coelho and I published some observations indicating that Indians living on a purely vegetarian diet rich in carbohydrates have a lower tolerance for carbohydrates, and suffer more commonly from glycuresis than the non-vegetarians, who take a mixed diet of meat and vegetables. They have been amply confirmed by subsequent work. Quite a large percentage of these persons pass sugar in the urine after the administration of the usual dose of 50 grams of glucose.

(*c*) Benedict, Osterberg, and Neuwirth have shown that in an apparently healthy person having no diabetic tendency, as much as 6 per cent. of sugar may be present after a breakfast rich in carbohydrates and in 24 hours the total sugar passed in urine may amount to 1·586 grams (·184 per cent.). If the same person is given an ordinary mixed diet, the total sugar passed is less. The output of sugar in urine after a meal follows a curve similar to that of blood sugar, but slightly delayed in time.

(*d*) Blood sugar acts as a stimulus to the Islet cells and regulates the secretion of insulin. When there is abundance of carbohydrate in the metabolism, the Islets are stimulated to produce more insulin than normal.

Thus in animals deprived of food for some days there is a more marked hyperglycæmia after the ingestion of glucose than animals on ordinary diet. In man a similar thing is observed. The rise of blood sugar which occurs with a dose of 50 grams of glucose becomes less marked when the dose is repeated, and ultimately there may be no rise at all. Repeated administration of glucose results in increased production of insulin, which lowers the blood sugar. Blood from a healthy person, who has been on a rich carbohydrate food, when perfused into a diabetic causes a fall of blood sugar as if insulin had been injected. But blood from a person who had fasted for 24 hours previously is without such effect. When insulin and glucose are injected together intravenously into a rabbit the fall of blood sugar is much lower than when insulin is injected alone. It follows that in a person a rich carbohydrate diet taken habitually, which would serve as a constant stimulus to the Islet cells, might ultimately cause their exhaustion thus producing a diabetic state.

II. *Obesity* and sedentary habits.

It is a common clinical observation that glycosuria is particularly common in obese persons who lead a sedentary life. If the weight be reduced within limits and regular exercise be taken, glycosuria is checked.

The same phenomenon is observed in dogs. Macleod compares the Diabetes in fat and lean depancreatised dogs, and summarises the facts as follows :—

A. *Fat depancreatised dogs :*

1. Death usually occurs about the fifth day preceded by symptoms of vomiting, coma, and anhydræmia.
2. After the coma appears, treatment with insulin sometimes fails to prevent death.
3. Hyperglycæmia is very marked.

4. Ketonæmia is marked.
5. D.N. ratio after the 3rd day is usually above 3·65.

B. *Lean depancreatised dogs :*

1. Animals may live for over a month. Vomiting may appear about the fifth day but animals usually recover.
2. The symptoms are very readily removed by insulin.
3. Hyperglycæmia is moderate.
4. Ketonæmia is not so marked.
5. D.N. ratio is much lower and may be well below 2 by the second week.

This shows that diabetes is in every way far more acute in the fat than in the lean animal. In the former, fat as well as protein is probably the source of gluconeogenesis.

III. *Mental Strain.*

The nervous control of insulin secretion is evidenced by the cross circulation experiments of La Barre which show that the Islets are controlled by the right vagus nerve, and its centre in the medulla, the adequate stimulus to which is provided by the sugar of the blood. There is a rich plexus of nerve fibres around the Islets from which fibres go directly to the Islet cell. These have been shown by McCrae and de Castro to be connected with the right vagus nerve. Section of this nerve produces a rise, its stimulation a fall of blood sugar. There is evidence that there are both excitatory and inhibitory fibres in the nerve so far as the Islets are concerned.

But apart from this, there is evidence of hormonal control. The influence of the following hormones may be considered :—

(*a*) *Anterior Lobe of the Pituitary gland.*

This secretes a *diabetogenic hormone,* without which lack of insulin produces no significant disturbance of carbohydrate metabolism. It is not quite clear whether this interrelationship is of the nature of *antagonistic action,* or if the pituitary hormone modifies the secretion of insulin in any other way. Some observers think that the Pituitary controls gluconeogenesis from proteins and fat. When this conversion is inhibited by the removal of hypophysis blood sugar level tends to remain unelevated in depancreatised animals.

(*b*) *The Thyroid Gland.*

In hyperthyroidism blood sugar is often raised and glycosuria occurs. This is due to excessive glycogenolysis. There is some evidence that thyroxin sensitises the Islets of Langerhans to secrete insulin. This influence may be indirectly through the anterior pituitary which produces a thyrotropic hormone.

(*c*) *The Suprarenal Gland.*

Adrenalin mobilises blood sugar, and there is hyperglycæmia resulting from excessive glycogenolysis. Its action is supposed to be opposite to that of insulin. Cannon and his associates have stressed the emergency function of the adrenal medulla. Under conditions of stress its secretion is increased, and it stimulates all the sympathetic nerve endings in the system. This happens in such conditions as fear, fright, rage, anxiety, pain, exercise, severe shock, exposure to cold, anæsthesia, asphyxia, etc. Perhaps here again the influence of adrenalin on insulin is indirectly through the anterior pituitary which is believed to produce an adrenalotropic hormone.

The influence of hormones on insulin secretion is probably more important and fundamental than the nervous control. But our knowledge regarding this is still very incomplete.

The fact remains, however, that in various emotional states hyperglycæmia and glycosuria occur, which perhaps through both nervous and hormonal relationship affect the secretion of insulin, thus tending to produce a diabetic state.

IV. *Prevention of Glycosuria.*

I need hardly stress the point that glycosuria is a common malady in India, especially in the middle and upper classes, and those belonging to the professions of law, medicine, etc. We do not know precisely what its incidence is. The mild and chronic type met with so commonly is undoubtedly due to dietetic indiscretion. Here the 'Diabetic Triad' of rich carbohydrate diet, obesity with sedentary habits, and nervous strain play an important part.

The essential problem of prophylaxis is one of *personal hygiene.* This is true of all metabolic diseases. It is the individual that we must get hold of, and instruct him that in middle and old age he should not eat too much carbohydrate, should avoid obesity and worry, and take regular exercise. Much can be done by extensive propaganda.

In addition to this, some measures of a public nature can be adopted. For advice and propaganda on a wide scale, Diabetic Centres may be established in different areas where all the laboratory aids to diagnosis are also available. The preventive measures though of a simple nature have not been fully appreciated. It is the duty of all members of the medical profession to spread the knowledge of prevention as widely as they can with all the means at their command.

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Discussion.

Dr. A. Gaffar spoke on the anxiety factor in the causation of diabetes. He examined the urine of 72 students who were preparing for an annual examination in Physiology and it was noticed that 7 of them had sugar

in their urines. A week after the Examination sugar disappeared from the urine of five of them, but in the case of one student who worked very hard there was intense glycosuria which was made worse as the student was taking a large amount of food. This glycosuria lasted for three months, and could not be controlled by even 60 units of insulin injection after the examination, and then disappeared. He accordingly concluded that anxiety may be an important factor in the high incidence of diabetes amongst clerks and earning members of a family. He further observed that diet alone without anxiety does not produce glycosuria, for amongst Choubes (a certain class of Brahmins) who are paid to eat a large amount of carbohydrate and fat the incidence of diabetes is practically unknown.

DR. S. N. HARDIKAR observed (1) that the occurrence of temporary glycosuria is well known in staphylococcal infections, and (2) that it is not so uncommon amongst the poor as is ordinarily believed.

DR. N. N. DAS supported the main contentions of Prof. N. M. Basu.

PROF. S. A. RAHMAN discussed glycosuria from the clinical point of view. He divided glycosuria patients clinically into the following four groups :—

(1) Group I—Patients suffering from renal glycosuria as indicated by a more or less normal glucose tolerance curve.
(2) Group II—Patients who suffer from temporary glycosuria after the attack of any disease, such as influenza. These patients are cured in the course of time without any treatment, dietetic or otherwise.
(3) Group III—Patients who are suddenly attacked with this disease probably due to some dietetic errors, for they are cured as soon as they are placed on a regulated diet.
(4) Group IV—Patients who cannot be cured by restrictions in diet alone but require insulin injection. These show a heightened glucose tolerance curve.

Apparently the last group alone had affections in the islet-tissue of the pancreas.

IV. THE NEED FOR A SOIL SURVEY OF INDIA.

Sections of Agriculture and Geology and Geography.

RAO BAHADUR B. VISWA NATH, President of the Section of Agriculture, in the chair.

The Chairman said that he counted it a piece of singular good fortune that it was possible for Sir John Russell to be present when this important subject was being discussed, in spite of his several engagements and pressing demands on his time. He said that he realised that Sir John was still touring the country and he could not, therefore, be expected to give his final and considered views on the subject, but he said that they would be grateful if Sir John would make a few observations with his wide experience of similar problems in other parts of the world and with what he had already seen in India.

The subject under discussion was 'The Need for a Soil Survey of India'. The answer to such a general proposition would undoubtedly be in the affirmative ; but the point for consideration was about the type of Survey. In arriving at an answer to this question, it would be necessary (1) to consider the objects of a soil survey, (2) to ascertain what had already been done in India and what was being done, and (3) to define what was wanted. A soil survey could be carried out for one or more of many purposes. For example, it could be carried out for settling new

land. It could be carried out for ascertaining the physical and chemical characteristics of the soil with reference to manurial treatment, and irrigation projects. In regard to the first point, there were about 150 million acres of cultivable waste land. All this land was, however, not situated in one compact block but was scattered in small patches all over India. It was necessary, therefore, in the first instance to ascertain the nature and the disposition of the waste land and this would perhaps form a subject of enquiry by the Departments in the provinces. During the past quarter of a century soil surveys were in progress in the different parts of the country to ascertain the manurial and fertiliser requirements of the soils. As a result, a considerable amount of valuable data were obtained and these were being used in advising on manurial programmes and fertility projects. In recent years, enquiries had been commenced in connection with irrigation and drainage problems with a view to ascertain the most suitable alignment for irrigation and drainage channels. There remained, therefore, the survey for the classification of soils so that the information obtained would be useful in interpreting the response to manurial treatments and for research and advisory work. They had, therefore, to consider carefully what methods of survey were needed for this purpose.

In England the basis of classification in the early days was geological, the assumption being that each geological variation gave rise to its own type of soil. Subsequently this was not found to answer the purpose, as the effect of climate, altitude, topography and other factors was considerable, so that soils formed from the same geological parent material varied considerably. Then there were the Russian and American methods of classification which were chiefly based on the study of the soil profile.

The soils of India could be very broadly classified into the Indo-Gangetic alluvium covering about 300,000 sq. miles; the tract of black soils covering a total area of about 200,000 sq. miles; and a red soil tract including laterite soils of 150,000 sq. miles. The black soils, although derived from different basic materials, possessed common agricultural characteristics and a silica alumina ratio more than 3. The large tract of the Indo-Gangetic alluvium was almost alluvial in nature. The soil profile in this case did not appear to be so important as it was elsewhere, but surely it should be possible to differentiate profiles even of this huge block of alluvium with reference to the relative intensities of rainfall, evaporation and temperature. The ratio of rainfall to temperature for the different parts of India varied from 0·10 to 1·5. A broad classification of areas might be made into—

North-East India,
North-West India,
North Central alluvial India, and
Peninsular India,

which again would be sub-divided on the ratio basis and classified with respect to texture and composition.

He would be glad if speakers would kindly bear in mind these points and confine their remarks to the methods of survey that might be considered necessary on an All-India basis.

The Chairman said that Mr. D. N. Wadia, Mr. P. K. Roy on behalf of Mr. A. K. Dey, Mr. H. G. Champion on behalf of Dr. R. M. Gorrie, Dr. A. N. Puri, Mr. Y. D. Wad, Mr. D. Bal and Dr. S. Kasinath would kindly speak in the order mentioned, and that our distinguished visitor, Sir John Russell, F.R.S., Director, Rothamsted Experiment Station, would kindly address finally and wind up the discussion.

D. N. Wadia (*Calcutta*).—The speaker stressed the importance of the study of Indian soils as separate entities. The fundamental differences of the soils of Peninsular India from those of Europe are illustrated by our Black Soils, Red Soils and Laterite, the clay fractions of which indicate a complex series of secondary changes resulting from high antiquity. European

soils being mostly of post-Ice Age origin and growth are far less mature than the soils of Peninsular India which have experienced no glacial erosion and renewal. Though no immediate economic benefit may result from a soil survey of the country, a number of important advantages may accrue by starting a systematic soil survey and mapping of selected type districts in each Province. To begin with, a soil survey need only be made of Peninsular India, together with a few special tracts of the Indo-Gangetic Plains, such as the exact delimitation of waste-lands, saline and alkaline soils, *usar*-lands, nitre-charged areas, etc. The most important benefit of a systematic soil survey will be the information that will be derived regarding the surface and underground water-supplies of the soils, marsh-lands, water-logged soils, etc. This inquiry is part of the soil survey and can be undertaken collaterally with it. Exact data regarding the character and behaviour of wells, tanks, the depth of the permanent level of sub-soil water and its fluctuations will be of immense value. Another gain will be the information regarding the distribution of humus in Indian soils. Exact knowledge of defects of humus in specified areas will suggest remedies.

The possibility of constructing a skeletal soil map of India on the scale of 32 miles = 1 inch from available information contained in the original small-scale maps of the Geological Survey of India and from the existing Revenue and Settlement records needs to be carefully examined.

The chief soil-groups of the Peninsula are largely determined by their geological foundation. The most obvious classification of the main soil-groups of the Peninsula is—Black soils; Red soils; Laterite; residual soils on granites; the soil-cap on basic rocks; on the Gondwana outcrop; on the post-Tertiary coastal sandy deposits; alluvial valley and coastal formations and minor soil belts. The approximate boundaries of these soil-groups are known; for their subsidiary divisions and mapping purposes a few hundred soil samples are needed from along each major boundary line. Only mechanical and rational analyses of soil samples will be needed, together with data regarding depth and character of soil-profiles.

S. K. Roy (*Dhanbad*).—A good deal is now-a-days being said about the independence of the nature of soil to that of the underlying rock due to the undoubted decomposition of which the overlying soil has been generated. It was said to-day and was spoken the other day in the Presidential address of the Agricultural section. But I do not believe that the importance of a geological knowledge of the underlying rocks to soil survey can be overlooked.

That the soil is dependent on Lang's Rainfall Factor is generally true, but instances are known where Geology can be seen to have direct relation with ground water, hence agricultural and geological knowledge could be of great use to mankind, the most important factor in agriculture. The classical example in this respect is that of the Weald in Sussex, where children drinking water from wells located in the Wealden clay, a rock poor in calcium, were found suffering from rickets, while those nearby, who were drinking water from wells situated in limestone areas, were absolutely free from that disease. In India I have seen that the cultivators of Bansda State, Bombay, a black cotton soil area with underlying Trap rock, burn leaves of various plants and trees on their paddy land for a good crop of paddy. This means that they are adding potash to the soil meant for rice plantation. Here the underlying rock, 'Trap', is well known to be poor in potash. Similarly, to have a good crop of lemon in Bengal, unless the villager adds lime to the root of the plant he cannot get a satisfactory result. The reason is that his soil, derived from the decomposition of the Himalayan granite and other rocks rich in potash, is poor in calcium which is an essential food of lime trees. These are a few instances where the geological relation between the underlying rocks and their resultant soils could not be absolutely overlooked.

Further, a knowledge of the underground water level is of great importance to agriculture. The determination of this is the work of a

geologist. In selecting dam sites for irrigation tanks—like those we saw yesterday—in selecting sites for wells for irrigation and for many other agricultural purposes, the geologist can help the Agriculturist a good deal. Some of the provincial well boring Departments could save a lot of money if they took advice from the geologists before pulling their tube wells and other wells.

The silica and alumina ratio, as has been suggested by one of the previous speakers, is of great importance to soil science. I do not know whethor these are combined or free silica and alumina. But if they are in a combined state, they are usually in the form of particles of various minerals whose identification, nature and property will be more easily understood by the help of the petrological and minerological branches of geology, than by any other means.

We Geologists have to roam far and wide in connection with our work, and our profession requires identification of rocks and minerals almost at a glance.

It is in these few words that I wish to point out that a Soil Survey of our country is necessary and that in this work the Geologist will be as useful as the followers of any other Science.

A. K. Dey (*Calcutta*).—The solution of problems in practical agriculture will be found either in the constituents of the soil itself or in its environment. Apart from the humus, the value of the soil depends largely on its nitrogen, phosphorus, calcium, magnesium, potassium, iron and silicon contents. Certain soluble salts are harmful to plants if present in quantity, e.g., plant life cannot prosper in fields close to copper, lead or zinc mines; while even beneficial salts are injurious to plant growth if present in large quantity. The presence of these mineral matters in the soil depends upon the kind of rock from which the soil is derived, but climate has also to be taken into account. Thus grey clay forms from the decomposition of basic rocks, such as dolerite, under English conditions, but laterite is formed from similar rocks under tropical Indian conditions. Topography exercises its influence through the movement of ground water, and different soils may be produced from the same rock according to whether the drainage is open, restricted or closed.

The aims and methods of soil survey may vary in different countries in response to local needs, but the object is everywhere the same, namely, to arrange soils into different categories according to their geological and chemical characters and according to the climatic and topographical features. The soils are grouped according to their profiles, their texture and other properties, and studied and correlated with laboratory help. Soil maps are then prepared showing the relationships of the different groups of soils present in a country. Just as geological maps are required in the development of mineral resources and for engineering projects, so, when the constitution of our soils is better understood, there will be demands for soil maps for practical agriculture, since soil surveys form the basis of work on soils, plant growth and agriculture.

The study of soils falls within that branch of geology which deals with the chemical and mechanical disintegration of rocks. Hence soil surveys are frequently included in the activities of geological surveys as in China, Germany, etc. On whatever lines a soil survey is developed, the services of geologists will be of importance to soil research.

R. M. Gorrie (*Dehra Dun*).—A paper on 'The Economic Importance of Changes in Plant Cover' presented to the Botanical Section of this Congress emphasised the vital need for protecting and maintaining a complete soil profile in all areas of importance for water catchment and storage. Practically all sloping grounds in the drier parts of India were of some importance as a source of water to the plains dwellers either for irrigation, town water or electric power, and its efficiency in catching and storing water depended very largely on how far the natural soil profile had been maintained and developed by preserving the natural plant cover. The importance of this function was now being fully realised in America

where very large sums of money were being spent in reinstating plant cover from areas whence it had been driven out or degraded.

Any form of soil survey which might be taken up should cater for that method of land use. The survey should register the relative efficiency of the existing plant cover in maintaining the optimum soil profile, and it should also indicate whatever changes were taking place in the building up or degradation of the existing profile. The view point which regarded soils *in situ* as entirely static and permanent would fail to give a record of permanent value because in many areas the soil profile was being rapidly destroyed through bad agricultural and pastoral practices. The soil survey must take cognisance of that fact and one member of each mapping party should be sufficiently erosion-conscious to be able to record obvious tendencies of this nature. The cumulative denudation which had been taking place in many parts of the western provinces was leading inevitably to desiccation. It was not, however, to be inferred that the total rainfall was being appreciably reduced, but that the ground was being rendered less capable of absorbing the available rainfall.

H. G. Champion (*Dehra Dun*) added that foresters were afraid that land allocated to a particular soil class recognised as suitable for some particular agricultural crop would be deforested to raise the latter without sufficient consideration of the soil's protective and water storage by the natural plant cover.

A. N. Puri (*Delhi*).—The important consideration was how to approach the problem and the methods of survey. He stressed the need for a committee of people actually engaged in soil survey, to co-ordinate their results and to chalk out an agreed programme of work for the future. The committee would suggest the best methods of approaching the problem. The Central Government could then be approached to subsidise those institutions and workers who were willing to undertake the work on agreed lines. The committee would first standardise methods so that all the results are comparable.

Y. D. Wad (*Indore*).—In many parts of India agricultural soils have been classified as well as mapped in detail for revenue purposes. The characteristics and agricultural properties of these revenue classes are well known both to the cultivator and to every body employed by the revenue department. Each class has its own local vernacular name. The classification is based upon the productivity as estimated at the time of survey. The factors taken into consideration to assess productivity may be illustrated with the help of typical examples collected from among the survey records of States in Central India, Bundelkhand and Rajputana :—

Table I.

Revenue classes of soils according to texture.

Type of soil.	Corresponding local names in			
	Alwar.	Datia.	Jodhpur.	Narsingarh.
Stiff clay ..	Chiknot ..	Mar ..	.... ..	Kali
Clay loam ..	Matyar I ..	Kabar ..	Kachar A ..	Bhur I
Sandy loam ..	Matyar II ..	Padua ..	Kachar I ..	Bhur II
Poor sandy or eroded clay soils.	(1) Bhur I (2) Bhur II	Rankar I .. Rankar II ..	Kachar II .. Kachar III ..	Patlon Badli

TABLE II.

Suitability of local soils to different crops.

(Datia.)

Local name of the soil.	Description of the soil.	Suitable for			REMARKS.
		Kharif.	Rabi.	Others.	
Gohan ..	Various ..	Yes ..	Yes ..	....	Near villages; well manured.
Mar ..	Stiff clay ..	No ..	Yes ..	....	Needs no manure.
Kabar ..	Clay loam ..	more ..	less ..	....	Needs manure.
Padua ..	Sandy loam	Cotton, Patwa ..	Gram, Barley ..	Sugar-cane, Tobacco (with irrigation).	Requires manure and irrigation.
Rankar ..	Poor; Sandy	Jowar, Bajra, Til, etc.	No ..	....	Three years under fallow after two consecutive harvests.
Tir ..	Silt ..	....	Yes ..	....	Flooded by rivers during rains.
Kondar ..	Sandy loam	....	Yes ..	....	....
Khadar ..	,, ,,	....	Tobacco, Sarson, Wheat.	....	Flooded by rivers during rains.
Kachar ..	,, ,,	Ground-nut	....	Chillies, Potatoes (with irrigation).	Rich soil; away from rivers.

TABLE III.

Crop producing of the soils in Alwar State.

Yields in mds. per acre.

Crops.	Chiknot.	Matyar.	Bhur I.	Bhur II.	Chahi.*
Barani Kharif—					
Cotton	5·6	4·0	3·2	3·2	8·0
Jowar	7·2	6·4	5·6	3·6	12·8
Maize	8·0	5·6	4·8	..	16·0
Bajra	7·2	6·4	5·6	3·6	11·2
Rabi—					
Wheat	8·0	7·2	6·4	4·8	16·0
Barley	9·6	8·0	4·8	3·2	22·4
Gram	6·4	6·4	4·8	3·2	12·8
Irrigated—					
Sugar-cane (local variety, Ratoon also) ..	500	500	..	..	..

* *Chahi* is that land which is intensively cultivated with copious irrigation and manure. Under each soil type land so changed is classed as a *Chahi* sub-group.

TABLE IV.

Typical common vegetation and the soils growing it.

(Alwar, Datia and Jodhpur.)

Vegetation.		Type of soil.	Corresponding soils in		
Local name.	Latin name.		Alwar.	Datia.	Jodhpur.
Dhao ..	Anogeissus pendula.	Light and poor soil.	....	Rankar and Padua.	....
Babul ..	Acacia arabica	Heavy rich.	Chiknot ..	Kabar and Mar.	....
Karil ..	Capparis aphylla.	Sandy ..	Matyar II and Bhur.	Padua and Rankar.	All the soils.
Shisham ..	Dalbergia sissoo.	Heavy but open.	Chiknot ..	Kabar ..	....
Pulash ..	Butea frondosa.	Poor clay ..	Chiknot and Matyar I.	Kabar ..	Kachar.
Karonda ..	Carissa Caranda.	,,	,,	,,	,,
Ber ..	Zizyphus sp.	Light soils and eroded heavy ones.	Bhur and Matyar II.	,,	,,

Other factors which have to be taken into consideration are:—

(i) Long continued intensive cultivation, e.g. *Gohan* in Datia; *Gevda* in Narsingarh and *Barah* in Alwar.

(ii) Different situations on the banks of rivers or streams, e.g. in Datia, *tir* when near, *Khadar* when subject to flooding, *khachar* when not so and *kondar* for higher terraces.

(iii) Special water supply existing at present, if artificial from tanks or wells: (*a*) Adhan in Malwa, (*b*) *Chahi maujuda* in Rajputana.

(iv) Seepage from natural sources, e.g. *Dehri maujuda* in Alwar.

When such water supply existed formerly but has subsequently disappeared even then the residual effects still remain and are taken into account, such soils are classified as *Fardia* in Narsingarh and *Chahi Sabika* and *Dehri Sabika* in Alwar.

Weed or jungle growth is also taken into account. Economic factors, such as vicinity to towns or markets and infestation by wild animals, affect the revenue, and hence such fields are put in a class other than the one to which they naturally belong. This artificial modification, however, affects a very small percentage and can be easily found out by local enquiry and observations on the nature of the parent rock, its depth and the degree of decomposition of its upper layers, the nature of the concretions fragmental materials and sometimes shells of fresh-water animals, existing in the profile and the movement of water table in different seasons. These features are specific to each revenue class which seems to have its own topographic aspect. Similar types, though with varying local names, are found in tracts widely differing in rainfall such as Bundelkhand and Rajputana. It appears that in spite of differences in the intensity and frequency of local precipitation and other climatic factors similar soils can be produced from different parent materials in situations where the

effects of erosion and moisture are capable of maintaining the same final equilibrium of residual and synthesised products. For instance, *chiknot* soils under the low rainfall of Rajputana are found in narrow ravines at the base of steep hills, while the similar *mar* soils in East Central India with its high rainfall are found in plains far away from the hills. This seems to agree very well with Mattson's (1935) theory of the degradation and the regeneration of the soil complexes. Such soil classes can probably be grouped as physiographic complexes described by Milne (1935). Both types of Catena seem to exist.

In parts of Rajputana occupied by soils derived from old alluvia the classes are characterised by the differences in texture natural to river deposits modified by the effects of wind drift and the present weather conditions.

Actual examination in the field in the summer of 1936 revealed the same profile characteristics for each soil class even when the spots chosen were situated in distant localities in the States of Datia, Rewa, and Bijawar. It seems therefore possible to accommodate the revenue types in the modern system of scientific soil classification. A large amount of practical information previously collected will thus be utilised and the mapping simplified. In the words of Crowther (1935) therefore, 'Would it not be wise to collect descriptions of soils which are already well recognised and named before attempting to lay down comprehensive systems of nomenclature and mapping ?'

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D. V. BAL (*Nagpur*).—It did not appear necessary to emphasise further the need for a soil survey, as this has been unanimously agreed upon at the last meeting of the Crops and Soils Wing of the Board of Agriculture and Animal Husbandry in India, held in February, 1935. He did not know why it was felt that the help of the geologists would not be sought for in the proposed soil survey work. As a matter of fact it had always been understood that the proposed survey should be carried out in co-operation with the geologists. He wished however to emphasise that, as mentioned by the previous speaker, the underlying rocks did not necessarily show any uniform relationship with the overlying soils, in a majority of cases in the Central Provinces. They had for instance many black soils derived from basalt which showed varying proportions of lime and potash, the former showing generally an inverse relationship to rainfall. They had black soils derived from different geological formations in the Central Provinces, but soils derived from the weathering of trap rock, in particular, which were black, heavy, and climatologically suited to the growth of cotton, were known as black cotton soils. The kind of crops grown on this class of soil depended, apart from its depth, to a large extent on the total amount and distribution of the rainfall.

He doubted if the existing revenue classification of soils could be taken as a basis for soil survey work as proposed by Mr. Wad. According to this system, clay content, depth and position of the land were taken as factors affecting soil productivity. A number of instances were met with in which

soils apparently alike differed considerably in productivity and a study of the soil (and soil profile if possible) in respect of important plant food constituents was likely to give the required information in regard to the factor or factors associated with soil fertility. A system of soil classification based on texture, position of the land, etc., although quite good up to a certain point and for the purpose for which it was meant, could not be considered to be entirely suitable for the proposed soil survey work.

As was previously mentioned by Dr. Puri it was necessary that, in work of this type, standard methods of analysis must be adopted and we must determine certain accepted constituents. This could be achieved only if some central organisation is constituted and funds for this purpose are provided by the Government of India.

Dr. Kashinath said that the subject of to-day's discussion is regarding the necessity for a survey of the soils of India. Considerations of feasibility or otherwise of such a survey are not pertinent and should not therefore influence our decision.

The answer to the above question should depend to a large extent on the kind of survey that is meant to be carried out.

If it is to consist only of an identification of the soil-forming rocks of the different soil-belts and their degradation products it is not likely to be of much use for agricultural purposes. It is no doubt true that the inorganic materials derived from the parent rocks constitute the dominating component of all soils ; and viewed broadly, a survey of the soils of a tract might appear to belong legitimately to the branch of Geology which deals with the chemical and mechanical disintegration of rocks ; but the agricultural behaviour of a soil is largely determined by the nature and extent of its clay fraction ; and a survey of this kind can furnish very little information on this point. Further, the recent findings of X-ray examination of soil clays go to prove the formation of a clay of uniform composition from different rock-materials and thus to argue against a survey of a more purely geological nature.

Another method adopted for the mapping of certain soil districts is the one based on the amounts of plant food present in them. This property of soils changes from time to time and is also easily altered by cultural conditions. Such soil maps will not therefore be of lasting value.

Nor will it be sufficient if the regional system of mapping our soils as was done in earlier years by the United States Bureau of Soils, were adopted.

As a result of the intensive work of the last two decades, the study of soils is now being placed slowly but none the less surely on a scientific basis ; and although pedologists are not entirely agreed to-day on a best all-round classification of soils, several systems have been well-nigh perfected ; e.g., the Russian System which is no doubt the first of the kind ; the Marbut classification based mainly on climatological considerations ; the subsequent elaboration and amplification of the latter by Milne and his co-workers in Africa, and by V. J. Koningsberger and E. C. Jul. Mohr in Java.

It should be admitted that judged from the standpoint of classification the present state of knowledge of Indian soils is undoubtedly meagre ; when therefore the scientific classification of soils becomes an accomplished fact the lack of a general survey of our soil belts will seriously handicap the progress of scientific agriculture.

India has a variety of climates and considerable stretches of fairly uniform agricultural land. In this respect one can see some analogy with Russian conditions. There are again, as in Peninsular India, apparently different types of soils lying side by side which, for aught we know, are traceable to the same parent material. Here it appears likely that topography and rainfall had played a more important part. The recent observations of Milne regarding the soils of Kenya may be found useful in this connection. In fact each soil belt may possibly be accommodated with suitable modifications in some kind of general system.

In a country like this which has to rely on uncertain monsoons, an assured future for its agriculture would be bound up largely with the feasibility of extensive irrigation projects. Further we have here several million acres of uncultivated land that remain to be opened up; under such circumstances a survey of our soils although not a necessity, is bound to prove of immense use.

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SIR JOHN RUSSELL then summed up the discussion as follows:—

First of all may I say how glad I am to be able to be here and how much I regret my inability to give an address this afternoon as desired by the Chairman and the workers here. Unfortunately my programme has already been filled. Further, in my remarks this morning I must confine myself to certain general statements: as your Chairman has pointed out, my journey throughout India is not yet completed and obviously at this stage I cannot be expected to put forward any final views. But already certain important points have emerged and these I can put before you.

I am not yet prepared to express any views as to the need of a Soil Survey. One's first instinct is to say that a Survey is certainly needed, but the Royal Commission thought otherwise, and their recommendations and opinions are in general so sound that one has to be sure of one's ground before disagreeing. Perhaps during the past ten years the situation has sufficiently altered to justify a Survey. On this point I express no opinion. I do not to-day propose to discuss this, but shall confine myself to indicating various directions in which local surveys can profitably be made.

In regard to the cultivable wastes of 150 million acres mentioned by Rao Bahadur Viswa Nath, one cannot help feeling that there is a good deal of it that could even in present conditions be brought into cultivation, and one advantage of a survey will undoubtedly be that it will enable us to ascertain which are the most promising areas for reclamation.

In regard to manurial experiments a good deal of information had already been obtained and this will be extended now that modern methods are being so widely used. It is, however, impossible to utilize fully the results of manurial experiments unless the soils are properly examined and characterised. A soil survey in relation to the area served by the experimental station affords an effective method of showing how far the experimental results are likely to be applicable in practice.

Further, there is the problem of Irrigation to which Rao Bahadur Viswa Nath has referred. I attach great importance to making a proper survey of any region that it is proposed to irrigate. In the past it has often happened, both in India and in other countries that engineers have completed the irrigation project and delivered water to the soil first without ascertaining what will happen when it gets there. Several expensive schemes have ended in failure and in the meantime the agriculturist has had to bear the burden. Trouble from water-logging is likely to follow irrigation unless the scheme has been planned as guided by a previous soil survey. I could give instances from different parts of the world which I have visited where the scheme considered from the engineering point of view has been admirable, but from the soil point of view it was bad. A preliminary soil survey is invaluable for indicating what part of the area can, with advantage, be watered and what part should not.

Coming now to the important problem of classification, several methods have been used. The earliest was textural: soils were classified

as sands, loams, clays, etc. This was useful but insufficient. Then came the geological basis, then climatic, then the profile basis. All are useful, but objection can be taken to all of them. Mr. Wadia referred to the geological basis of classification. The difficulties in regard to this arose from the important part played by the climate in making the soil. Geological data, however, are invaluable for providing information in respect to water-supply, where it is essential to know the nature and position of the various strata, their permeability and their relation to the ultimate supplies of water. Studies of this kind would be useful in famine areas.

Other problems of soil survey arise in connection with forestry. Forest conservation is an effective way of reducing or even preventing soil erosion. A vast scheme has been projected in the United States where millions of acres of land have been ruined by erosion, for planting up a great forest belt 100 miles long and 10 miles wide ; it will take something like a hundred years to complete, but it is hoped that it will be effective in preventing a good deal of erosion that is now taking place. Soil erosion is one of the problems that no country can afford to neglect, and certainly India cannot neglect it.

There is another important problem India owes to Soil Science in the rest of the world. It was in South India that Buchanan many years ago first described certain soils as lateritic and so introduced a totally new group of soils to scientific workers. Soil Science has changed a great deal since then and there has been a great deal of discussion as to what is and what is not a laterite soil. J. B. Harrison showed that apparently similar soils occur widely in British Guiana : Scrivenor has described them in Malaya and Mohr in Java : they have been widely recognised in Africa. But India remains as the land of their birth, so to speak, and it is in India that they should be fully studied. What are they ? What are their agricultural properties ? How can they be improved ? A good deal of work has been done in recent years in the West Indies and in Africa. In India there are great opportunities for further studies. You must remember that the idea first arose in India and you are in a good position for developing further knowledge.

Another set of problems on which you are in an almost unique position for study is in connection with the black soils of India. These are entirely different from the black soils of Russia, though apparently they are something like some of the black soils of Africa. You are able to supply the information about the soils which soil investigators in many other parts of the world are desiring.

Reference was made by Mr. Wad to the admirable data collected by the Revenue Department. This Department has considerable knowledge of the relative values of the soils and indeed India is better served in that respect than many other countries. The basis of classification adopted by the Revenue Department is essentially the soil texture modified by such factors as depth, proximity to water-supply, duration and intensity of previous cultivation, etc.

One of the modern methods of soil survey is to base it on the soil profile. Unfortunately, most of the Indian soils I have seen have no very marked profile such as can be seen in other parts of the world. A good deal of soil work is being done in India and it would undoubtedly be a great advantage to put all local surveys on to a uniform basis so that the results can be collated and brought together. It is not necessary to adopt any one basis of classification. Soil investigators are by no means agreed on the matter, and numerous systems have been proposed. The important point at the present time is that the soils should be fully described and that the same methods of description should be used by all Indian workers. Dr. Puri's suggestion is sound that the Indian soil workers should constitute a committee to draw up an agreed basis for describing the soils and should indicate the methods of examination to be adopted. It would further be necessary to arrange for some central body

or for some institution to collate the results and prepare the maps and so to put data on record that will be useful to all concerned with soil management and with agriculture.

V. CONDITIONED REFLEXES.

Sections of Physiology and Psychology.

LT.-COL. S. L. BHATIA, President of the Physiology Section, in the chair.

S. L. BHATIA (*Bombay*).—The main facts about the Conditioned Reflexes are no doubt known to you all. They are well established. They may be briefly described. Pavlov has introduced a new method for investigating the normal functions of the central nervous system and especially of the higher centres. He divides all reflexes into 'unconditioned' and 'conditioned'. The '*unconditioned reflexes*' are inborn and transmitted by heredity. The conditions in which an animal lives do not influence their formation. All the spinal and bulbar reflexes including the viscerial, somatic, protective, postural, feeding and sexual reflexes belong to this group. They are probably the basis of 'instinct'. The '*conditioned reflexes*' on the other hand are acquired during the life of the individual. Consequently they are individual in their destribution and unlike unconditioned reflexes do not belong equally to all the members of the species. The conditions in which an animal lives determine their formation. Adaptation to environment depends on the power of the individual to acquire new conditioned reflexes,—on his power to learn, unlearn, and learn again according to the variations in the conditions in which he lives. It is not known to what extent these reflexes are hereditary. They are characteristics of the higher animals, in whom the brain possesses a vast amount of 'associations' between different centres, and the faculty of discrimination and judgement. They originate in association with well established unconditioned reflexes, which form the substratum. Quite a number of such reflexes may be developed around a simple inborn reflex. 'The higher the animal's nervous system, the greater the number and complexity of the conditioned activities it presents' (Lovatt Evans).

You all know the classical example of a conditioned reflex. When food or acid is placed in a dog's mouth, a reflex secretion of Saliva is produced, which can be collected from an artificial fistula and measured. This is an unconditioned reflex, with its centre in the medulla, and can be elicited in a decerebrate animal. Now if a second indifferent stimulus, e.g., a sound is applied when the animal is being fed or just before, and this act is repeated a number of times, its sound becomes an adequate stimulus for the production of saliva, even without food or acid in the mouth. This is a conditioned reflex. At first the reflex is diffuse but by further repetition and training it becomes localised, so that a particular note only will evoke a response. In the dog a differentiation between a note of 800 and one of 812 vibrations can be established. This differentiation is due to a precess of internal inhibition.

For these experiments the salivary gland is used most often, because the response (secretion of saliva) can be determined quantitatively. But visual, tactile, and all types of sensory end-organs and many varieties of stimuli can be used to establish these reflexes. Apart from salivary secretion, the other varieties of responses used are the contractions of skeletal muscles, reactions of the pupil, changes in the heart rate, gastro-intestinal movements and secretions, respiration, and reactions of the vasomotor system.

The conditioned reflexes are of two varieties, namely *positive or excitatory*, and *negative or inhibitory*. The conditions necessary for the

establishment of the *positive reflexes* are that the animal should be in good health, the conditioned stimulus must begin to operate before the unconditioned stimulus is applied, and slightly overlap the latter. An alert mental condition of the animal is necessary. The cerebral cortex must be protected from other conflicting modes of stimulation. For this reason, the experiments are carried out in a dark, sound proof room away from the observer, who watches the animal through a window. Almost any stimulus can become suitable if properly applied. It is necessary that it should be followed or ' reinforced' by the unconditioned stimulus. ' Trace ' conditioned reflexes, either ' short ' or ' long ', are established when a definite interval elapses between the conditioned and unconditioned stimuli. Even ' duration of time ' may become, a conditioned stimulus.

New conditioned reflexes can be established by ' linking ' the action of a new stimulus with a conditioned reflex already established. They are known as ' secondary ' conditioned reflexes. Tertiary, quaternary, and other reflexes without end can be established in man ; but in dog tertiary reflexes are the limit. This phenomenon of ' *linking* ' indicates the manner by which the most complicated associations are developed in the cortex by building one reflex upon another. This function is acquired by each individual, the process being one of *signalisation* by which a ' signal ' or an unconditioned stimulus evokes the same response, as the stimulus with which it has been primarily associated.

The conditioned reflexes obey certain physiological laws, namely summation, irradiation, specificity, discrimination, reinforcement and linking.

The *negative conditioned* reflexes cause inhibition instead of excitation. They are due to the faculty possessed by the cortex of discriminating between the stimuli, so that unsuitable responses do not occur. These reflexes are of various sorts, but probably the ultimate mechanism of all is the same. This inhibition is an active process and it may be external or internal. External inhibition is due to the presence of an extraneous stimulus and may be temporary or permanent. It appears to depend on the impulse rather than on the acquired properties of the cortex. Internal inhibition is dependent on the inhibitory discharges from the cortical cells. It occurs when the conditioned stimulus is repeated without the accompaniment of the unconditioned stimulus. Its examples are the phenomena of inhibition by *extinction*, conditioned inhibition, inhibition by retardation and differential inhibition. There is again the phenomenon of ' disinhibition ', or inhibition of inhibition, by which inhibitory process can inhibit another so that original excitatory reflex occurs.

The conditioned reflexes are a function of the cerebral cortex. The primary function of the nervous system, according to Pavlov, is to maintain a dynamic equilibrium between the functional units within the self-contained system of the organism and between the organism as a whole and its environment. The pre-eminent function of the lower parts of the central nervous system is to integrate the activities of the separate parts within the organism. But the most delicate adjustments between the organism and its environment are pre-eminently the function of the cerebral hemispheres. Removal of the cortex abolishes all conditioned reflexes, and prevents the formation of new ones. Localised damage produces partial loss, but the establishment of inhibitory reflexes becomes particularly difficult. The cortex is therefore an important inhibitory again.

The *Reflex arc* according to Pavlov is divided into three parts :—

1. The part that begins in every natural peripheral end of the centripetal nerve and ends in the receptor cell in the central nervous system. This is known as the *analyser*. The task of this consists in decomposing the entire world of stimulating influences falling on the organism from the outside. The higher the animal, the finer is their decomposition.

2. The part which must join the brain end of this analyser with the effector apparatus. This is known as the *connection* or *lock*.
3. The working apparatus or the *effector* organ.

Pavlov asserts that the cerebral hemispheres consist of sensory or receptive centres, e.g., the brain endings of the analysers. It would appear that a considerable part of the hemisphere is composed of these analysers. The occipital and temporal regions are of course the centres for eye and ear respectively. Even the so-called motor centres should also be considered receptor centres from another receptor surface which has a special relation to movement.

The peripheral apparatus, the analyser, consists of a number of so-called transformers which convert different forms of energy into nerve energy. *And conditioned reflex is an act of synthesis by the cerebral cortex, the whole of which is concerned with the reception of impulses.* Irradiation and concentration are fundamental laws of higher mental activity.

Conditioned reflexes thus offer us the means of objective investigation of the activity of the central nervous system. They have certain important applications in the case of man. They are probably the basis of training and education, and are related to the 'behaviour' of the individual. Formation of 'habit' depends on acquiring certain conditioned reflexes.

Man's capability to develop links in the conditioned reflexes seems to be unlimited. This greatly increases the scope of his activity. 'A signal to which an animal was previously indifferent acquires executive power; it becomes a spring of further action. It amplifies the animal's behaviour. The new connection improves with use, under disuse it disappears. It can therefore hardly be morphological. Professor McDougall is trying to see if it is heritable. Anyway the great new surface net of the brain is educable. Before it, truly, there were educable systems in the animal world, but this is so educable as to be practically a new thing in the world. In the dog it can acquire these new links even in a few repetitions, and links can be combined even to the third degree. In man it seems they can develop almost without limit'. (Sir C. Serrington.) Thus the human brain is capable of being educated almost endlessly. The study of conditioned reflexes also shows the plastic adaptability of the central nervous system by means of which adjustment to external environment occurs.

Another interesting outcome of this work is that it has been found that dogs show marked individual differences in regard to the *facility* with which their reflexes are acquired. In some they are more stable than in others. Some acquire the positive or the excitatory reflexes more easily, others the negative or the inhibitory.

Thus Pavlov divides his dogs into 4 different groups, namely two extreme groups of markedly excitatory and inhibitory animals, and two central groups of well-balanced, equilibrated animals, but also different—one being quiet and the other exceedingly lively. These results are applied to man, who is said to possess four types of *temperaments.* The ancient grouping of temperaments according to Hippocrates into choleric, melancholic, sanguine, and phlegmatic is essentially correct. The excitatory type is the choleric, the inhibitory is the melancholic. The phlegmatic type is well-balanced self-contained and quiet, while the sanguine is also well-balanced and energetic, when there is a constant stimulus, but in the absence of a stimulus it becomes slothful. In an extreme case the excitatory choleric type merges into the pathological form known as neurasthenia, and the inhibitory melancholic type into hysteria. Thus this knowledge also helps us to understand the various forms of psychoses.

In considering the functions of any organ in the body, as physiologists, we think in terms of chemical reactions, production of heat, action potentials, exchange of energy, the structure and functions of individual cells.

In the case of brain also, we consider all this. In addition to this, we have in conditioned reflexes an objective method of studying some of the responses that occur in higher animals to stimuli. But in studying the functions of the brain, it is impossible to divorce mental process from the physiological. What is the relation of these two processes to each other ? How does one influence the other ? Have they both a common origin ? Are mind and matter two different things ? Pavlov says that they are not. 'We are now coming to think of the mind, the soul and matter as all one, and with this view there will be no necessity for a choice between them.' He thinks that this dualistic theory has kept physiologists from working with the higher nervous phenomena. May it not be that in order to understand fully how the brain works, we require the joint efforts of Physiologists and Psychologists.

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K. C. MUKHERJEA (*President, Psychology Section*).—There is a belief that the various branches of psychology have made progress just in so far as they have freed themselves from the trammels of consciousness and introspection. Hunter proposes to scrap the word 'psychology' altogether and to substitute the new term 'anthroponomy'. But no one could be more drastic in the exclusion of conscious events than the German objectivists. They objected, for example, to the use of the term 'ear', because the ear is the organ of hearing. We have, they thought, no right to assume that organisms hear ; let us use, they said, the term 'phonoreceptor'. Similarly, we have no right to assume that an animal sees ; let us use the term 'photoreceptor'. This behaviouristic spirit early in its career fell in with a powerful ally, namely, the doctrine of 'Reflexology' or the 'Conditioned Reflex' which developed independently in Russia. Russian reflexology was the creation of two men—Bachterev and Pavlov. The former while collaborating with Spirtov reported experiments on an 'artificially associated respiratory motor reflex' in the dog. If cold be suddenly applied to the skin there occurs in dogs (as in ourselves) a well-marked reflex catching of the breath. Bechterev noticed that, if another stimulus is repeatedly applied at the same time as the cold, it will eventually start off the same reflex when given by itself, will in fact act as though it were a substitute for the 'natural' stimulus of the reflex. Even before Bechterev's discovery of the 'associated reflex' Pavlov had found a similar phenomenon in what he called the 'conditioned reflex'. He observed that a dog would secrete saliva, not only when given food, but also when presented with a stimulus that was associated with food. The dogs could be trained to salivate at varying periods after the conditioning stimulus (the so-called 'trace reflex'), and such astonishing accuracy in the measurement of time was shown that a suitably trained dog would salivate exactly thirty minutes after the stimulus, no reaction being obtained even at the twenty-ninth minute.

This conditioned reflex has gradually become one of the principal methods and working concepts of behaviourism. Indeed, it would seem

to afford an almost unlimited field for research. Mateer, using a method devised by Krasnogorski, trained young children to open their mouths to receive a chocolate bit whenever they received a touch on the arm. The children, who ranged in age from three to seven, were also submitted to intelligence tests, and it was found that both the development and the extinction of the conditioned reflex were more rapid in the case of the more intelligent children. On the conative side, Watson has been able to establish conditioned fear reactions to a number of stimuli, as when he showed the child an animal at the same time as a loud voice was heard, and found that a fear reaction subsequently occurred at the appearance of this animal. Conditioned reflexes of this kind are very difficult to extinguish, and Watson himself believes that such experiments reveal to us the way in which are formed the irrational phobias of the neurotic. Indeed by many behaviourists the conditioned reflex is regarded as the pattern on which all modifications of conduct are acquired. It is believed that all learning is simply conditioning, and that the conditioned response is the true unit of learned behaviour.

It seems that the conditioned reflex has for the behaviourist taken over the part formerly played by the 'association of ideas'. Behaviourism, as thus interpreted, is indeed a sort of objective associationism; Watson may perhaps be looked upon as the twentieth century representative of the position occupied in the nineteenth century by James Mill, and much the same objections may be, and have been, brought against both attempts at the abolition of purpose or activity of mind.

The meaning of a word is, according to this school of thought, nothing but a conditioned response to that word. If, for example, the child reaches toward a bottle, and the word 'bottle' is repeated many times in connection with it, then in the course of time saying the word 'bottle' will produce in the child the reaching movement; a conditioned response has been established. What the word 'bottle' means is the behaviour in reference to the bottle. The associationist view that words arouse simply ideas is altogether abandoned. So the difficulty of the conditioned reflex in explaining the enormous difference of behaviour to the slightly different stimuli—'your son is dead' and 'my son is dead' when destitute of ideas—is hardly met satisfactorily. The theory of the conditioned reflex still deals with the fundamentals of behaviour lower in order and chooses a point of view which practically presents the matter upside down. In understanding a business we should approach the directors and not plague the office boy or the stenographers. The arrangements in the spinal cord may be easily investigated, but still here the simple process of conditioning is not quite clear. How are we to conceive the effect—namely the watering of the dog's mouth—of the conditioned stimulus (the note)? Is it satisfactory to think of either as the storing in some neural cells of an image of food which bobs up to co-operate when the note is sounded or a channel in the neural pathways opened or enlarged? The cell-doctrine or the drainage theory is no doubt tempting. But the former is altogether exploded and the latter is still popular. The drainage theory is groundless without the theory of lowered resistance of which it is practically an extension. Conditioning is effected by the association of the stimuli—say the sounding of the note and the giving of the food, but surprisingly enough no conditioning takes place if the note is sounded after the food is given. The note is to be sounded before or contemporaneously with the giving of the food for the conditioned act of salivation. But the explanation that the final common path having its synaptic entrance resistance sufficiently lowered gets used to the intruder is not enough. For if we go on sounding the note the resistance should gradually be more decreased and the flow of salivation should be more copious, but on the other hand we observe that the salivation soon ceases altogether, if the note is not from time to time followed by the natural stimulus—the food. So the physiological requirements of the resistance theory are not enough for the conditioning. We find no phy-

siological ground here for the discontinuity of the path opened for salivation at the sounding of the note. Further soundings of the note should have deepened the path, but the path is in fact closed, instead of being deepened. The synaptic resistance which has been lowered by the mere passage of the impulse should not or cannot be raised by its further passages. Indeed what is lacking here is something mental. The note is changed in meaning, for it being dissociated with the food no longer excites the dog's need for food and consequently the salivation. Thus the reflex theory is indeed bankrupt here. And even Prof. McDougall believes in some psychical guidance of the neural discharge when his drainage theory is found inadequate.

N. S. N. Sastry (*Mysore*).—Ever since Pavlov conducted the brilliant experiment on conditioning a reflex to a foreign stimulus, the concept of 'conditioned reflex' has become increasingly prominent in psychological discussions. Some became exuberantly enthusiastic and believed and preached that all behaviour, even the most complex human behaviour, could be explained on the basis of 'conditioned reflexes'. Some accepted it with more caution and are slowly trying to use it as a more rational basis of explanation of behaviour than the other older concepts which have won the sanction of tradition and usage. There are, of course, the third group of people who deny the possibilities of the concept and cling desperately to older ones.

But there are a number of psychologists who readily recognised the place and value of 'conditioned reflexes' in psychological literature. They have tried to show how conditioned reflex, as a notion, could fit in the general accepted doctrines of psychology.

It would be a pitiful waste of time to describe what a conditioned reflex is. Every student of Psychology and Physiology knows almost all that is to be known about it. Its compositional nature—the significance that a new stimulus acquires—the instability of conditioned reflexes—its specificity even within the same receptor—the extinction—irradiation—inhibition—all these have been very exhaustively dealt with not only by the father of the doctrine of 'conditioned reflex'—Pavlov, but by a number of modern writers in Psychology.

But the great Pavlov displayed unmistakable signs of hesitation in applying the concept of 'conditioned reflex' to explain human behaviour. He, at best, said that analogically to the case of the dog, we might try to apply the principle to human behaviour. He tried to explain human pathological breakdowns like hysteria on the basis of the concept of the conditioned reflex.

But those who came after (should it be before) him, led by Watson, believed that Pavlov had found out an 'Open sesame' to all problems of psychology. We are all aware—sometimes painfully aware—how Watsonians (certainly a better term than behaviourists) have told us that learning is nothing but a case of conditioned reflex. A rat is let loose in a maze with food placed at the goal. The rat gradually learns to avoid going into blind alleys. It learns to do this piece of work without a mistake. Watson tells us that this and all other (human) cases of learning are merely cases of conditioned reflexes.

Organisation of our affective life is explained away—rather suggestively vehemently—on the basis of conditioned reflexes. Watson's famous experiment on conditioning a boy's fear to a rat is very well-known. But most of our emotive reactions are not unrelated originally to the native stimuli. In the case of the dog experimented upon by Pavlov (and many of his collaborators) the secondary stimulus is unconnected with the primary. The ringing of the bell or sounding the tuning fork has no relation biologically or otherwise with food. But Pavlov established a significance to even an unrelated stimulus! Be that as it may, in emotive reactions the native stimuli have a relation with the type of emotive reaction determined by racial experience. To be afraid of certain objects and flee from them was certainly useful for the organism.

So these emotive reactions were bound up with certain kinds of stimuli. But these reactions are controlled by the cognitive and executive facilities. So what is really effected is a propensity for emotive reaction.

And we know, if we accept McDougall's idea, that these emotions are characteristic psychic accompaniments of instincts. Hence, when Watson says that affective life is controlled by conditioned reflexes we must note that the propensity as a whole becomes affected, which fact denies the possibility of a mechanistic explanation.

Memory, the unconscious mental life, and all the rest of psychic experiences are explained by Watson and others on the basis of conditioned reflexes. The author of the concept could never have anticipated that this concept would be used to explain behaviour on a mechanistic basis. The great danger of the use of this concept is its misuse. Conditioned reflex, properly understood, should show how a mechanistic explanation, specially of human behaviour, is impossible.

This is partly seen by the phrase 'conditioned reflex' becoming changed to conditioned response. Reflex pure and simple rarely occurs, if at all. The simplest behaviour pattern that matters is sufficiently far removed from pure reflex. So conditioned reflex cannot explain all behaviour. Reflex explanation itself is not adequate. The higher, more complicated, and better integrated type displayed in instinct is a case of 'response'. So when the phrase 'conditioned response' is increasingly made use of we see that modification of the notion of conditioned reflex is necessary before we can even make use of the idea of conditioning.

In fact the idea of conditioning is much more useful for us than that of conditioned reflex. Conditioning is capable of understandable explanations. Let us take an example from conditioning the affective life. Man is not a source of fear for young ducks when first they come across him or he comes across them. The mother duck flies to a distance of safety as soon as she sees man—exhibiting all the signs of fear. But the young ones are absolutely fearless. But before this human individual approaches them a second time, the mother has come to her youngsters, exhibiting fear. Now the man approaches. All the young ones show fear. Fear has become conditioned to man. In this case the whole propensity to flee has become conditioned. The organism has undergone a change. There is change in the meaning. So the propensity till now accessible to other fearsome objects than man, has now become accessible to man—the new stimulus. Thus we see that conditioned response makes it impossible to have a mechanistic explanation.

In some instances, one single incident suffices to establish a conditioned reflex, though sometimes many such incidents are necessary. Why should it look natural for certain types to become conditioned to some foreign stimuli? Then look at the extinction of the conditioned reflex. Repetition of the bell stroke (reinforcement) was necessary for the dog. The dog then expected food. The reaction was by the whole organism. The sound of the bell became significant of hunger propensity. But when this propensity is roused uselessly, as when no food follows the bell, this conditioned reflex becomes extinct. This can be explained—as Dr. Rosenthal has done—on the basis of mentalistic explanation only.

Then, look at the parallel between suddenness of acquiring conditioned responses and insight. It is plainly suggestive that purposive action is seen when such conditioning takes place. In the case of the dog there seems to be no doubt that there was conscious expectation of food when the bell was rung after conditioning was established.

So we see that more important than the idea of conditioned reflex, is the idea of conditioning. The teaching of conditioned reflex—more specially of Pavlov—shows how it explains most types of behaviour but not as behaviourists explain. The idea of conditioned reflex—which is a fact—and the possibility of a mentalistic purposive action are not incompatible.

PANDIT UDAI BHANU.—The subject of conditioned reflexes is very fascinating. Its study may be grouped under two headings, which for convenience may be called psychological and physiological. The psychological study has to do with the explicit development of the process of conditioning; Physiological, with the anatomical topography and processes underlying.

Two points suggest themselves :

I. Does conditioning leave any physiological trace in the neural mechanism, and if it does can it be localised ?

II. Can cortical function be explained in terms of the principles governing spinal reflexes ?

Each of these two concepts is the centre of considerable discussion. You will note that all of them belong to the physiological aspect of the phenomenon. Reflexes can be quantitatively measured and experimentally demonstrated. They are observable even without instruments and hence do not afford much material for discussion.

Let us discuss each of them successively :—

I. In order to understand thoroughly the changes that take place in the nervous structure we must have its microscopic view during the process of conditioning; but unfortunately this is not possible under the present state of knowledge. It is, therefore, the subject only of inference.

The changes in the afferent nerve endings in a receptor organ to the stimulation are conveyed to the cortex where certain other physiological changes are produced. Some psychologists affirm that the physiological events in the cortical cells are the true representation of the corresponding changes that occur in the receptor cells.

Direct stimulation of the spinal tract transmits the frequency of stimulation to the muscle fibres unchanged; but if the stimulation takes place through the cortex, the frequency of contraction does not always correspond to the stimulation. The cerebrum does not only translate afferent impulses into efferent ones but is an integrater of them.

The human central nervous system is especially adapted for preserving, within itself, the discreetness of individual impulses. The brain and higher connective tissues represent, apparently, the most extreme development of the synaptic type of nervous organisation. Sherrington in his 'The Integrative Action of the Nervous System' says: 'Each synapse indubitably represents a distinct separation of parts in the total conductive structure used by any given response'. By means of this synaptic arrangement, therefore, each stimulus is enabled to preserve its identity within the organism. The synaptic nervous system is capable of representing extraorganically determined stimuli groups.

Herrick in his 'Neurological Foundations of Animal Behaviour' terms this new type of synaptic material 'junctional tissue', or 'membrane of separation'. The inter-neuronic energy generated by stimulation of this junctional tissue by a simple nerve impulse is supposed, by Sherrington and other physiologists, to possess entirely different characteristics from the inter-neuronic energy propagated within the individual neurones involved in the response. This super-neuronic type of energy, found only in the synaptic nervous systems, may conveniently be called psychonic energy. Any unit of junctional tissue within which psychonic energy is generated may be called a psychon, in contrast to the neurone within which neuronic or nervous energy is released.

This psychonic energy is capable of producing a physiological trace in the cortex. It may be added that plants and lower animals are incapable of harbouring within them unit energy groups representing corresponding environmental stimuli.

Campbell says that the cyto-architectural divisions of the cortex are considerably more numerous than the gross morphological divisions known as lobes.

When we consider the wide ranges of individual differences in capacity and output we are led to think of some degree of localisation. In accordance with the general evolutionary principle of progress by specialisation, we would consequently expect more and more definite localisation of certain functions which are capable of being localised.

Extirpation of parts of the cortical region gives data favouring specificity. The function of speech is isolated in the area from the posterior part to the parietal and temporal lobes to the level of the angular gyrus as far as the foot of the frontal convolutions. The results of the pathological studies during the great war, in which lesions of almost every type occurred for observation, give positive evidence favouring rather than opposing specificity.

Let me give an abbreviated sketch of the process of conditioning from the behaviouristic view-point which will serve as a basis for discussion. All responses, the behaviourists say, of striped muscle, smooth muscle, or glandular tissue consist of reactions to stimulation from efferent nerves. The connection is morphological, and therefore inherited. A stimulus activates an afferent neurone. It sets up an electric disturbance in the nervous system, eventually in the cortex. In an area such as the cortex, whole fields rather than individual cells must be the functional units. Integrated acts of daily life involve the complex interplay of stimulation through many receptors plus the conditioning that has occurred before. They are, therefore, the results of the activity of the entire cortex rather than the specific part of it. Memory, intelligence, imagination and many other complex functions cannot be localised.

Localisation of certain functions and the disturbances which occur when injury is done to the centres are not the infallible proofs in support of the theory of specificity. What is said of the nervous system is equally true for the heart, bones, glands and muscles. A simple eye-hand coordination will be disturbed if the heart is diseased, or the bone is broken, or a gland is inactive, or a muscle is impaired.

It is on these grounds that the behaviourists feel themselves justified in denying the theory of cortical specificity.

II. In the study of conditioned reflexes we arrive at the following conclusions :—

(A) The conditioned reflexes are variable, impermanent.
(B) A number of repetitions is required to establish an unconditioned stimulus to a reflex.
(C) The dying out of all reflexes after a particular period.
(D) Loss of acquired material.
(E) The cerebrum can exert an inhibitory influence on conditioned reflexes.

Slow acquisition, fluctuation and rapid loss are the characteristic signs of human conditioning. We are conditioning new reflexes, or grafting new stimuli on to the old.

Certain energy changes in the environment act selectively upon the nervous system and activate specific groups of the effectors. Thus the process of conditioning proceeds from crude to accurate adjustment.

The cerebrum can react only to one thing at a time. Application of another stimulus will either be ineffective or will inhibit the process initiated by the first stimulus. A band is passing on the road. I wish to continue my reading of this paper but fail to inhibit the external force. It stops my act of reading for the time being.

A reflex is very delicate and subject to immediate influence of an abnormal condition in the nervous system. Thus strong stimuli lose their effect while weak stimuli become quite potent. Cases of hysteria invariably support this. You will find innumerable examples even in normal cases. The mother is very sensitive to the slightest cry of her child, yet she may be quite insensitive to other things even nearer.

This evidently suggests that the influence of the cerebrum on conditioning is greater than that of the spinal cord. Now the question is, can cortical functions be explained in terms of the principles governing spinal reflexes ?

VI. WEGENER'S THEORY OF CONTINENTAL DRIFT WITH REFERENCE TO INDIA AND ADJACENT COUNTRIES.

Sections of Geology and Geography, Botany, and Zoology.

Mr. W. D. West presided, and opened the discussion with a brief review of the theory in general and of the difficulties raised, and referred to alternative solutions that had been put forward.

B. Sahni (*Lucknow*).—[*Note.* As space forbade more than a very condensed statement here, most of what I had to say in the way of an advance abstract was published last November in a fuller statement elsewhere (*Sahni, 1936*; see also *1935, 1935a*). But the present summary takes into account facts and opinions which came to my knowledge afterwards, either during the course of the discussion, through correspondence or otherwise. In recording my remarks here I have found it more convenient to put them into a continuous statement, rather than in the form usually adopted in symposia.]

The main facts of the Gondwana glaciation have always strongly urged me in favour of Wegener. But speaking, as I should, only as a palæobotanist, I confess that my position until recently was that of an agnostic. Latterly I have felt myself drifting gradually towards Wegener's idea of continental displacements. But whereas Wegener applied his evidence chiefly to the disruption of a Pangæa by the *drifting apart* of its fragments (a view which may later find more palæobotanical support than it seems to have at present) I have tried to elaborate what may be regarded as a complementary counterpart to his theory : *a drifting together of continents once separated by a wide ocean.*

From a broad survey of the late Palæozoic floras two striking facts emerge : (*a*) some countries with closely related floras lie on the opposite sides of the biggest oceans of the globe, e.g., China and western North America ; eastern North America and Europe ; India and the southern continental blocks (*Sahni, 1935a, fig. 1*).

(*b*) Other countries with very distinct floras lie dovetailed with each other, e.g., the Gondwana province of India-Australia and the *Gigantopteris* province of China-Sumatra (*loc. cit., fig. 3*).

Can we explain these facts without the aid of continental drift ?

Let us consider separately the two broad facts under (*a*) and (*b*).

(*a*) If Wegener is right, the corresponding floras of regions once contiguous but now far apart ought to show, if not an identity, at least a much closer resemblance than might be expected on the theory of land-bridges. In 1926 an attempt was made to compare the southern fossil floras from this point of view (*Sahni, 1926, pp. 231–233*). This attempt proved abortive because our knowledge of the floras of corresponding points on the opposite coasts was too unequal to admit of a fair comparison. Du Toit (*1927*) has since compared the geological features of the opposite shores of the South Atlantic ocean. This comparison has lent strong support to Wegener's theory. But palæobotanically the position today is much the same as it was eleven years ago.[1]

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[1] Though attention should be drawn to some recent works on the subject (see *Shaparenko, 1925* and literature cited by him, especially the works of *Irmscher, Koch, Kräusel, Studt* and *Wulff*).

(*b*) We might, however, attack the problem from another angle. We might consider the relations of two very distinct floras which lie close together on the map: the *Gigantopteris* flora of China and Sumatra and the *Glossopteris* flora of India and Australia. The striking contrast between these two roughly contemporaneous floras has been clearly brought out in the works of T. G. Halle (*1927, p. 289*), Jongmans and Gothan (*1935*) and Kawasaki (*1927, 1931*). It is so striking as by itself to raise the suspicion that the two floras, one essentially of northern affinities, the other southern, must have lived in different climates. Indeed the current view is that the *Glossopteris* flora was probably evolved in a temperate climate on a continent just emerged from glaciation, the *Gigantopteris* flora in a warmer climate analogous to that of the European coal measures (*Seward, 1933, pp. 253ff.; Sahni, 1931, p. 270*, see also *Norin, 1924; Halle, 1927, pp. 11, 12, 291-292*).

Is it conceivable that these two floras should have evolved and flourished side by side, where we now find them on the map: facing each other along a NS front of at least 28 degrees of longitude? As suggested elsewhere, this apparent anomaly is at once explained if we assume that the two provinces originally lay far apart, north and south of the Tethys, and have since drifted towards each other. This conclusion, already foreshadowed by Halle's work (*1927, pp. 280–290*), has been elaborated independently by Fromaget (1934) and the present writer (*1935, pp. 245–247; 1935a, pp. 388-389; 1936, pp. 323-324*). Jongmans (*1935, p. 242*) has also been led to conclude that the relations of the Sumatra flora cannot be explained without the aid of the drift theory. In this drift, the resistant promontory of the Gondwana horst in N.E. Assam must have played an important part, resolving the movement into two components, one acting from the north, the other from the east.[1]

The broad palæobotanical facts, when read in conjunction with Wadia's work on the syntaxis of the N.W. Himalayas (*1931*), seemed to lead irresistibly to the conclusion that we have here another syntaxial angle, even more marked than that in Kashmir. On a reference to Mr. Wadia I was gratified to learn (February, 1935) that he had himself arrived at the same result; that, in fact, the idea was by no means a new one: several geologists had already thought on the same lines, and all the recent work had tended to confirm the idea. It must suffice here to refer the reader to the original writings of M. Fromaget (*1934*), Professor Arnold Heim (*1936*) and Mr. Wadia (*1936*); also to the remarks offered by Professor Kenneth Mason on the last two works and on a paper by Kingdon Ward (*1934*).

Until the end of last year we had no actual proof of a structural continuity of the Himalayan axis round the NE. corner of Assam: this much needed field evidence was announced by Mr. P. Evans during the course of the present discussion (January 7th, 1937). The view of Kingdon Ward (*1934, 1935*) that the Himalayas extend eastwards from Assam right across China, and that they have nothing to do structurally with the meridional mountain ranges in Burma, had already been shown to be untenable on various grounds by Kenneth Mason (*1934, 1936*), by Wadia (*1936*) and by the writer (*1936*).[2] With Mr. Evans's direct evidence of a

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[1] Possibly Central Sumatra, with its southern outpost of the *Gigantopteris* flora, may have functioned as a southward salient of the advancing East Asiatic block, deflecting the tectonic boundary with Gondwanaland either into a NE. trend so as to pass somewhere between Borneo and Tonkin (*see fig. 3 in Sahni, 1935a, or 1936*) or eastwards so as to pass between the northern coast of Australia and the East Indian archipelago; but on this point opinion must be reserved till reliable palæobotanical data from the eastern part of the archipelago are available.

[2] From a paper just received (Feb. 20, 1937) from Capt. Ward (*1936, p. 136 footnote*) I find that he now accepts the geological continuity of the

structural flexure round the Assam corner this view seems to lose all chance of support. Mr. Evans holds the view that the compression in this region is probably something like 200 miles from an original width of at least 600 miles.

It would be interesting to know how far the peculiar radiating form of the river system in SE. Asia, with so many of the main rivers bunched together opposite the NE. corner of Assam, is connected with the earth movements suggested above. Prof. Kenneth Mason (in *Wadia, 1936, p. 69*) considers it highly probable that at least the majority of the rivers in this region of intense compression are true strike rivers. Could this fan-like drainage system have resulted from a 'spreading' movement in the sense of Gutenberg (*1936* and earlier papers; see also *Lake, 1933*), combined with the Polflucht force, involving a rotation about the vertical axis situated at the tip of the Assam promontory?

The above explanation of the anomalous relations of the *Glossopteris* and *Gigantopteris* floras is opposed to that put forward by Ting and Grabau (*1934, pp. 7-8*). These authors presumably believed that geographically the two floras have always occupied their present geographical positions, and explained the sharp contrast between the two floras as being due to the presence of an intervening basaltic plateau which extended in a wide NS. belt in SW. China. This plateau, however, is not known to have extended further south than the southern border of China. Apart from the improbability of such a plateau remaining effective as a barrier for any appreciable period of geological time even where it did exist, this hypothesis leaves unexplained the anomaly of two climatically distinct floras lying athwart the same latitudes along a front of something like 2,000 miles. On the other hand, the assumption that the barrier was provided by the ocean now represented by the longitudinal mountain belt in the Assam-Burma-Malaya region seems readily to explain the sharp contrast between the two floras.

During Permo-Triassic times some intercourse across the Tethys seems to have been possible between India and the Far East, as also between the Gondwana and Angara continents (*Wadia, 1934*, see *Sahni, 1936a*). This is indicated by stray Gondwana elements both in the Far Eastern and in the Angara flora.

As regards the Gondwana element in Angaraland, it may have crossed by way of a late Palæozoic archipelago which Zalessky had postulated in 1918. Geological evidence of such an archipelago has since been found by Wadia in the Kashmir portion of the Tethys and by Mushketov in Eastern Ferghana. In reply to an enquiry Professor Mushketov writes (in a letter dated 14-1-1937 for which I am deeply indebted to him and which he has allowed me to quote here) that he had demonstrated in 1928 that in Eastern Ferghana, between the meridians of 70° and 75°E., many isolated dome-like elevations were formed at distances of only 10 to 50 miles apart, which presumably would suffice to account for the suggested migration.

At the same time we must seriously consider Professor Halle's (*1936*) objection that it is difficult to reconcile the migration hypothesis with the supposed position of India during the Permian according to Wegener. In Wegener's reconstruction India lay far to the south, near Madagascar, which itself was not far north of the Pole; while Siberia lay near the Permian equator. The point is that if Wegener's map is correct, then not only would the distance between India and Siberia have been too great to allow of any easy migration across an archipelago, but the two floras must also have been situated in very different climatic zones.

It must be admitted at once that the problem of the Gondwana element in Siberia is by no means easy of solution. But in any case the

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Himalayas with the Arakan Yoma, but he considers the latter, on biological grounds, 'as a minor divergence of the main range' which he presumably still regards as extending eastwards right across China.

idea of an independent origin of so many similar forms of life on two completely separated continents scarcely seems credible. On the other hand the question of migration is bound up with a number of obscure factors. In the first place, does such a migration demand nothing short of an actual land connexion between India and Siberia ? If not, what was the kind of distance over which an archipelago or a chain of islands might have served as an effective means of transport ? This again would depend, *inter alia*, upon the modes of dispersal available to the plants in question, and upon the geological date within the Permian when the migration took place. The distance to be traversed may have been considerably less towards the end of the Permian than during the glacial period, when India presumably lay further south.

In the absence of a plausible alternative the migration theory seems the only one in the field at present. It has at least the merit that it was suggested independently, long before the discoveries of Mushketov and Wadia.

Between the Indian and far Eastern floras there was much less in common, but the few points of resemblance that exist may suggest another route of migration across the Tethys, perhaps in the region of the Assam promontory of Gondwanaland.[1] But the main point of concern to us here is that the whole of the region just east of the Tethyan belt must be regarded *essentially* as a province distinct from Gondwanaland. This view is in consonance with the idea expressed above that these regions have drifted westwards while the Burma-Malaya mountains were being uplifted.

If, as some geologists believe (*de Terra, 1935 ; Wadia, 1936*), the Himalayan uplift is still in progress, this fact may provide indirect evidence that the continental displacement is still going on. Accurate readings of latitudes and longitudes in the region between Szechuan and Celebes on the east, and in Hazara and Afghanistan on the west, if continued over a long enough period, may yield direct proof of the suggested pivotal movements round the Assam and Kashmir promontories. Possibly the suggested northward displacement of the Australian block may also be checked directly by observations of latitude. But it appears that the practical difficulties in the way of reliable observations in the critical regions are still too great to inspire hopes for the near future.

During the course of the discussion my attention was drawn to that ingenious modification of Wegener's views,—Gutenberg's Fliesstheorie (*1927*) recently restated by him (*Gutenberg, 1936*; see also *Lake, 1936*). The differences from Wegener refer essentially to the physical and geophysical aspects; for the location of the continents and their movements relative to the poles both Wegener and Gutenberg rely upon the evidence of geology and palæontology. For the palæobotanist it is obviously impossible, on present evidence, to decide whether the continents (if they have moved at all) reached their present positions by a process of drift or of flow. But the mechanics of the movement apart, Gutenberg seems to introduce a fresh difficulty in the way of even accepting that the con-

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1 In a paper just received (23-2-37) from Nanking, C. H. Pan (*1936*) describes some early Mesozoic plants from NE. China. From the Yenchang formation in Shensi (which he correlates with the Upper Trias, possibly passing upwards into the Rhaetic) he figures, *inter alia*, specimens provisionally referred to the characteristic Gondwana species *Schizoneura gondwanensis*, '*Danæopsis*' *Hughesi* and *Noeggerathiopsis Hislopi*. He adds that if these latter species are correctly identified a route of migration from India to China must have existed, a possibility suggested by the writer in 1926 (*Sahni, 1926, p. 240*), and again in 1936 (*pp. 322, 327*). Whether the species are identical or more or less closely allied their interest in this connexion is obvious. See also Yabe and Ôishi (*1928*).

tinents have moved at all considerably from their original positions. 'According to the Fliesstheorie, the bottoms of the Indian and the Atlantic oceans are formed of sial' (*Gutenberg, 1936, p. 1589*). And for all we know this sial may represent foundered land bridges. This submerged sialic connection between the continents (if it exists) is supposed to be thinner than the continental blocks, but in any case the matter is speculative.

These speculations naturally suggest investigations of the sea-bottom. The available data, geological and oceanographic, indicate that the northern part of the Arabian Sea covers a foundered tract of land which once connected India with Arabia and Somaliland. The foundering appears to have resulted from block faulting due to compression possibly related to the Himalayan orogenic forces. But as these phenomena did not occur till late in the Tertiaries, and very little is known of the earlier history of the Arabian Sea, they can have no direct bearing upon the much earlier history of Gondwanaland. In any northward drift (or flow) that is postulated during the Permian a much larger block than merely the Indian peninsula may have been involved. It may thus still be possible to reconcile the recent history of the Arabian Sea with the fundamental idea of continental movements during the late Palæozoic.

Conclusion.—Thus if we have not yet enough palæobotanical data to prove the *drifting apart* of the different remnants of Gondwanaland, we at least seem compelled to agree that movements of large magnitude elsewhere have *brought into juxtaposition* continents once separated by the ocean. We cannot get away altogether from the idea of continental drift, although the details of Wegener's theory must stand on their merits. Whether palæobotany can help us to choose between this theory and Gutenberg's modification of it must for the present remain an open question.

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P. EVANS (*Digboi*).—The evidence collected mainly by the geologists of the Burmah and Assam Oil Companies strongly supports the suggestions of Prof. Sahni and others that structurally and stratigraphically there is a definite continuity around the head of the Assam Valley.

S. L. HORA (*Calcutta*).—There are two views regarding the geographical relationships of the Indian freshwater fish fauna. It is generally believed that there is a considerable African element in the freshwater fauna of India, but Day in the seventies and eighties of the last century showed that the freshwater fishes of India contain a very large proportion of the Malayan element. The present writer has found considerable evidence to support Day's hypothesis both from the systematic study and distribution of several families of freshwater fishes and from the geological evidence that has been made available by the researches of Prof. J. W. Gregory on the evolution of the river systems of South-Eastern Asia. It may now be stated that the freshwater fauna of India was derived by successive waves of migration, consequent upon extensive river-captures, from east to west. Additional evidence has thus been found to support Pelseneer's view that the freshwater fauna probably originated in the seas of Indo-China.

The relationships and the geographical distribution of the various genera of the Schilbeidæ are discussed at length and the evolution of the family is traced from the less specialized forms as they migrated from east to west. Reference is also made to the peculiar distribution of the fish genera *Silurus*, *Pseudecheneis*, *Parapseudecheneis*, *Bhavania*, *Catla*, *Catlocarpio*, *Psilorhynchus*, *Gyrinocheilus*, etc. and it is indicated that the relationships of some of the remarkable genera of India can only be explained on the assumption that their ancestral forms migrated from Indo-China, Siam, etc.

The facts adduced by the writer concerning the origin and the geographical distribution of the Indian freshwater fishes negative the theory of the permanence of oceans and continents, for they postulate the existence of a land connection between India and Africa. As to whether this connection was in the form of a 'land-bridge' between the two continents, or the two continents were juxtaposed at some remote period but later drifted apart, it is very difficult to decide. The abrupt change in the form of the African and Indian Schilbeidæ is certainly the result of some form of isolation, and before this occurred presumably the Indian forms were of the same type as are now found in Africa. The higher specialization of the Indian genera can be accounted for by the

fact that India was a centre of great disturbance during the Tertiary period owing to the earth-movements that gave rise to the Himalayas, whereas Tropical Africa with its large lakes provided a stable environment for its fauna, and the specializations of animal organization noted in this region are those that can be definitely correlated with life in comparatively calm and clear waters.

It is generally believed that the land connection between India and Africa, more particularly Madagascar, disappeared at the transition from Cretaceous to Tertiary. It is during the obscure interval between the late Cretaceous and the Eocene periods, however, that nearly all the modern types of bony fishes originated. As regards the Cat-fishes (Siluroidea), to which the Schilbeidæ belong, there is no evidence that the group has any great antiquity, as their first appearance is indicated by some fossils in the Tertiary deposits of the highlands of Pedang in Sumatra, where remains of some of the living genera have been found. The Schilbeidæ are found from Indo-China to Africa, and the same is the case with the Cat-fishes of the families Clariidæ and Bagridæ, both of which seem to be more ancient than the Schilbeidæ. A remarkable feature of the Schilbeidæ is that no member of the family is found in Ceylon which would indicate that Ceylon became separated from India at a stage earlier than the disappearance of the land connection between India and Africa.

S. P. AGHARKAR (*Calcutta*).—A study of the distribution of the African species of the Indian flora has led the author to the view that these species have reached India at different periods. The oldest of these, which may be called the Palæo-African element of the Indian flora, must have reached India towards the end of the Jurassic and the Cretaceous period when there was a direct land connection between Peninsular India and Africa through Madagascar. This element is exemplified by the sub-family Borassoideæ of the Palmaceæ, the genera of which (*Borassus*, *Hyphæne*, *Medemia*, *Lodoicea*) are restricted to these parts and of which *Borassus* is the most widely spread. It could only have spread over India, Madagascar and the present Continental Africa during this period. The disjointed distribution of some species belonging to Asclepiadaceous genera Sarcostemma and Ceropegia also points to the same conclusion. The distribution of the genus *Euphorbia* sect. *Diacanthium*, which is restricted to Africa, the Canary islands, Madagascar and Arabia, is possibly to be ascribed to the same age. On the other hand species of the Araceæous genera *Arsæma* and *Sauromatum*, which are particularly well developed in the Himalaya and are of Asiatic origin must have reached Africa in late Tertiary times.

A number of species common to Africa and India must have reached India through Arabia, South Persia and Baluchistan after the present coastline of the Indian Ocean was fixed.

The author is of opinion that the occurrence of the Palæo-African element in India is better explained by Wegener's theory of continental drift than by any other hypothesis.

J. D. H. WISEMAN *and* R. B. SEYMOUR SEWELL (*Cambridge*).—During the course of the John Murray expedition some 20,000 miles of the floor of the Arabian Sea and the neighbouring areas of the Indian Ocean were mapped by means of the echo-sounding apparatus. The region between India and Africa was crossed four times, namely :—

(I) from Aden to Karachi,
(II) from Bombay to Mombasa,
(III) from Zanzibar to Colombo,
(IV) from Colombo to Aden.

The data obtained show that the region is traversed by several submarine mountain chains, namely :—

(A) Interrupted ridges 60 miles off the coast of Baluchistan and Persia, probably part of the Zagros System of Persia.

(B) A double ridge with an enclosed deep gully, running south-west from Karachi across the entrance to the Gulf of Oman. The ridge on the north-west of the gully is probably a continuation of the Kirthar range of Sind. These ridges and gully may be connected with
(C) The great Carlsberg Ridge running from Socotra south-east to the Chagos Archipelago, and then south-west perhaps to the island of Roderigues.
(D) A ridge running concentric with and south-west of the Carlsberg Ridge. It may be continuous with
(E) The curved ridge of the Seychelles-Mauritius Bank.
(F) The Seychelles-Madagascar Ridge.

Fragments of rock from the top of the Carlsberg Ridge and from the deep basin on its north-eastern side all proved to be of basaltic type. The analyses of three of these show that they differ strikingly from the average composition of the Deccan trap, containing less total iron and less potash. They are unlikely therefore to be a westward continuation of the Deccan Trap.

There is a remarkable similarity between the topography of the floor of the Arabian Sea and the region of the Great Rift Valley in Africa, the one being the mirror image of the other on either side of meridian 50°E. Minor earthquake belts running down both the Rift Valley and the Carlsberg Ridge afford further evidence of similarity, and also indicate that the earth's crust is still unstable along these lines.

Geodetic observations by E. A. Glennie suggest that the Laccadive Archipelago is a continuation of the Aravalli Mountains; and it also seems likely that the Laccadives are separated from the Maldive area by faulting, the former showing positive anomalies and the latter negative anomalies. Geodetic work of Bullard in East Africa suggest that the Rifts have been formed by horizontal compression and not by tension.

It has long been recognized that the west coast of India has been formed by extensive scarp faulting, while Blanford postulated a fault running along the Makran and Baluchistan coast. The northern part of the south-east coast of Arabia and the African coast from Cap Guardafui southwards to Mombasa are also due to extensive scarp faulting. Hence the whole of the northern part of the Arabian Sea is surrounded by a series of faults. Blanford and others have dated the fault down the west coast of India as Pliocene or post-Pliocene. The subsidence of the Murray Ridge, if it is a continuation of the Kirthar range, must be post-Miocene. The faulting along the south-east coast of Arabia must be Pliocene or post-Pliocene. The topographical similarity between the Carlsberg Ridge and the Great Rift Valley suggests that they are contemporaneous, i.e. early Tertiary in age.

It seems highly probable that the floor of the north-western part of the Indian Ocean assumed its present form as a result of compression in Tertiary times contemporaneous with the Alpine-Himalayan folding; and that subsequently, in Pliocene or post-Pliocene times, a tract of land occupying this area became faulted down to its present depth. There is little or no indication that any older continental mass or land isthmus, such as the hypothetical continent of Gondwanaland, or the isthmus of Lemuria, ever existed except in the granitic mass of the Seychelles and perhaps the corresponding granites of Sokotra and the Kuria Muria Islands. These may all be intrusives, similar to the intrusive granites of the Himalayas.

W. D. West (*Calcutta*).—The gradual increase in thickness of the Deccan trap towards the west coast, where it reaches its maximum thickness, suggests that it once extended far into the Arabian Sea. Its disappearance is unlikely to have been due to marine denudation, and must be due to faulting. Direct evidence on this point is provided by

recent deep borings in Kathiawar and Gujerat, which indicate that the trap here has been faulted down to at least 2,000 feet below sea level.

It is well known that Kathiawar was a special focus of igneous activity during the Deccan trap eruptions, and produced special rock types not found elsewhere in the Deccan trap. The extrusive types include very basic varieties rich in fresh olivine and augite, designated ankaramite and oceanite. These have been analysed. Precisely similar rock types, and of the same age, occur in north Madagascar, and have been described and analysed by Lacroix. Two alternative conclusions can be drawn. Either Madagascar was once close to Kathiawar, and partook of its peculiar Deccan trap rock types; or similar conditions of differentiation prevailed in the two areas at the same time, and produced the same rock types. The latter is the more probable, but the possibility of the former should not be entirely excluded.

P. Evans (*Digboi*).—Any of the various drift hypotheses require the movements of large blocks of country, and it is desirable to enquire into the evidence bearing on the extent of lateral movement in India.

In the hills bordering the Brahmaputra Valley in Upper Assam it is possible to make a very rough estimate of the minimum movement since late Tertiary times. In the Naga Hills, on the south-east of the valley, the Tertiary succession is repeated by nearly parallel overthrusts which in some instances are inclined at only small angles to the horizontal. It has been shown that these folded structures represent the extreme phases of asymmetrical anticlinal folding. An attempt to estimate the amount of lateral shift accompanying these faults indicates that in the Naga Hills over a breadth of 20 miles the contraction is at least 100 miles and probably much more; that is, the 20-mile zone was at least 120 miles wide before the Pliocene folding. This however is only the portion of the folded zone that has been studied in some detail; further in the hills there is an even broader area of crushed and disturbed Eocene rocks which must also have undergone much lateral movement. This suggests 200 miles as a minimum for the lateral shift in the Naga Hills.

On the other side of the Brahmaputra Valley are the Himalayan ranges with overthrusts presumably much more intense than those on the south-eastern side of the valley, and although there is no direct evidence from this little-known tract it would seem reasonable to postulate at least as great a degree of horizontal movement; if so, points once 600 miles apart on the opposite side of the Assam Valley are now only 200 miles apart and there has been a contraction of 400 miles.

It does not seem possible to condemn Wegener's hypothesis merely on account of the magnitude of the postulated drift when there is this evidence of late Tertiary lateral movements of several hundred miles, although this is, of course, much less than the total movement required by the hypothesis.

Gutenberg, from seismic work, proposed a theory of spreading out of a sial land mass originally occupying most of the southern hemisphere, and suggested that during spreading there would be a tendency for folding and mountain-building to occur at the equator and also at the advancing margins of the spreading land. Wade has shown that Gutenberg's hypothesis receives support from the curious distribution of oil. In certain regions oil-forming conditions have recurred at intervals since Cambrian times; in some other countries oil is limited to the Tertiary beds, and in yet others it is all but absent. Oil formation and preservation require certain conditions of sedimentation and folding which are most likely to be present in the equatorial regions, and Gutenberg's hypothesis postulates that North and Central America have travelled along a path which has kept them near the equator for a very large part of geological time—so greatly favouring the formation of oil. By contrast, South America, Africa and Australia remained for a long period too far from warm equatorial conditions for sufficient organic matter to be available and were also unfavourably placed for folding and sedimentation.

The occurrence of oil in India and Burma and neighbouring countries appears to fit in with Gutenberg's hypothesis. Wade has suggested that the subject deserves further consideration, particularly from petroleum geologists.

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L. RAMA RAO (*Bangalore*).—When Wegener put forward his theory of continental drift, it was generally welcomed as it at once seemed to offer a possible solution for several geological and biological problems which had till then baffled all attempts at explanation. But as a result of a closer and a more careful examination of the theory in the light of observations that have been accumulating during the last few years, it is coming to be increasingly realized that this hypothesis is not quite so acceptable. In discussing the validity of this theory, we must naturally focus our attention on the history of the earth during the late Palæozoic and early Mesozoic periods. Any conclusions based entirely on Tertiary and post-Tertiary phenomena will not be useful.

In the northern hemisphere, recent studies from various aspects of the geology of the countries on either side of the Atlantic by Washington, Chamberlin, Gregory, Mrs. Reid and others have shown that the features on the two sides do not fit in as Wegener imagines. In the southern hemisphere with which we are more concerned in the present discussion, the theory has been examined in its bearing on two problems: (1) the distribution of the *Glossopteris* flora and (2) the Permo-Carboniferous glaciation. From one or the other of these points of view the theory has been critically examined within the last 15 years by several leading geologists and palæontologists, and none of them find any evidence in support.

The remarkable case of two originally distinct floral provinces (the *Glossopteris* flora of India and Australia and the *Gigantopteris* flora of China and Sumatra) now seen in close juxtaposition and even dovetailed with each other to which Dr. Sahni has drawn attention, no doubt suggests a movement of these land areas *towards* each other and therefore seems to support the general idea of a continental drift. But in view of the fact that the theory has been tried and found wanting in the solution of the more major problems of geological structure, paleoclimates, and former distribution of faunas and floras, it seems doubtful if we have still to invoke the aid of this theory for explaining this occurrence. No other explanation may just now be possible; but in course of time, with a more detailed knowledge of these two contrasted floras and a better understanding of the factors controlling life distribution, it is quite probable that we may discover an alternative explanation without involving such drastic and large scale movements of land as are contemplated in Wegener's theory. While certain slow and minor lateral movements of land in some areas may no doubt have taken place at certain periods in the past,

yet they do not seem to be of the kind, nor are they on the scale, postulated by Wegener; and even then, these movements must have formed only a part of the numerous factors which have determined former climates and past distribution of faunas and floras.

MR. H. G. CHAMPION asked the President if any information were available bearing on the time relationships of the hypothetical continental drift. The President replied briefly that as it was a question of millions of years, very little could be said regarding the rate of movement.

C. S. FOX (*Calcutta*).—The uplift of an ocean floor with its deposits of marine sediments into a mountain range such as the Himalaya is good evidence for believing in the instability of lands and seas. The geological history of the Indian peninsula, however, shows that it has remained a land region since the middle Palæozoic era—roughly 250 million years ago—and is evidence in support of the belief in the remarkable permanency of continents. Thus two adjacent regions in India supply contradictory evidence in regard to an important geological question and it is to be concluded that the truth must be in some theory which permits both possibilities. This nice compromise appears to be best attained, according to some geologists, in an hypothesis which involves the lateral displacement or so-called drift of the continents.

The idea of the continents behaving like rafts which break across, split up and drift apart on a sub-crustal magma, like icebergs do over the ocean, is not a new one, and was evidently first put forward over 75 years ago by Snider. Nearly half a century ago Koken discussed the possibility of the shifting of the earth's axis and of wandering polar regions to account the Gondwana glaciation, but his theory is mechanically impossible. At about the same time Eduard Suess wrote of the mountain chains of Southern Asia as if in movement and advancing in a series of great folds towards India and Africa. Continental drift as a world phenomenon was discussed 25 years ago by Taylor as a general creeping of the crust towards the equator due to an increase in the rate of the Earth's rotation. The hypothesis was, however, elaborated five years later by Wegener who accepted the view that the light granitic continents were afloat on a basaltic stratum which is hot and plastic, and that, due largely to the rotational effects of the earth, the continental rafts tended to drift towards the equator and westwards.

In the hope of finding evidence for the southward drift of Asia, an examination of the records of latitude observations in India through the past hundred years was made but only yielded contradictory results. The differences in latitude which were noted were thought to be due to errors of observation rather than to actual changes in latitude. It is admitted, however, that a drift of six inches a year along a meridian—i.e. a change in latitude only—might remain undetected. At such a uniform rate of travel the distance from the antarctic to the equator would be accomplished in a little over 65 million years, i.e. roughly since the beginning of the Tertiary era. Actually the movement would move faster and faster from the pole to the equator. The mathematical objection to the theories which assume that the rotational effect of the earth is the prime cause of continental drift, is that the available force is quite inadequate to drive the continents over a sub-crustal layer which is not molten at present.

The general hypothesis of continental drift helps to explain so many features of geography and geology and, in particular, gives a complete solution to the mystery of the great Ice Age of Gondwanaland—one of the unsolved problems of Indian palæogeography—that it requires the most careful consideration. If it could be established that the available motive forces were sufficient, or that they periodically became able, to cause the continents to drift, not necessarily towards the equator or westward, but in the direction of least resistance, then the theory would be widely accepted. It is thus worth while to examine the available evidence and see what may have been overlooked, or whether any new data can

be made to give an answer to the question—Do the continents 'creep' with respect to the plane of the equator and in process of time change their latitude and longitude?

Immediately before the Permian period Gondwanaland, which included the Indian peninsula in a large southern continent, was evidently buried under a great ice sheet very much like Greenland today. This inland ice worked northwards and floated away as icebergs on the sea which then covered the Salt Range and north-western India. We are thus presented with the problem of explaining, how, 200 million years ago, antarctic conditions on a regional scale could occur in an area which is now largely within the tropics. It is believed that at the time of the Gondwana Ice Age the peninsular of India was part of a very elevated country which included what is now the Bay of Bengal. Judging from the distribution of the Lower Gondwana sediments of the Permian period the drainage of this upland region was northward. There appears to have been one wide basin trending northwards up the present Godaveri valley towards the Satpuras and having an outlet towards Rajputana. Another drainage area extended from near Cuttack north-westwards up the Mahanadi valley of to-day into Rewa where marine beds occur. A third area appears to have been eastwards into Bengal and north-eastwards to the Eastern Himalaya where marine conditions were present. This third area, quite the most extensive, appears to have joined a wide basin which was supplied from a land area to the south—presumably a basin over what is now the Bay of Bengal. There is evidence of land conditions at this time in Lower Burma, but there was clearly a great sea extending from Tenassarim to north-east Assam and then westwards over practically all the area of the Himalayas and so into the Punjab in Permian times.

A careful consideration of the distribution of the Lower Gondwana sediments and the conditions under which they appear to have been laid down suggest that warm conditions, possibly a temperate climate, had already been established before the middle of the Permian period, and that a mountain range existed on the line of the Aravallis; that a watershed existed between the Rewa and Satpura Gondwana basins of those days; that another watershed was present between the Rewa basin and the Damuda basin or lake region of that epoch. The fact that the drainage of all the Gondwana basins, especially the first two—up the Godaveri into the Satpuras and up the Mahanadi into Rewa—was northward gives strong support to the belief in a great mountain tract along the coastal tract of the east coast of the peninsula. The coal basin in Bengal and the eastern Himalayas is so large and so shaped that a large drainage area from the south is suspected. That there was a land region in this direction is indicated by the presence of Lower Gondwana coal measures in Tenassarim. Submarine volcanic activity appears to have already occurred in the Kashmir region when the icebergs were floating northwards from Gondwanaland over the Punjab Salt Range, and these eruptions evidently heralded earth movements in north-western India which brought the northern shore line into or close to Kashmir in the Permian period.

A further amelioration of climate and a regression of the sea had begun before the close of the Palæozoic era. There was also submarine volcanic activity in the Kashmir area which initiated the rise of the land as a result of new earth movements. Arid tropical conditions were developed early in the Mesozoic era and the climate in the Indian peninsula was so severe that the rich *Glossopteris* flora died out in the Triassic deserts of Gondwanaland. Submarine activity again broke out in Kashmir, and in Afghanistan, at the close of the Triassic period, and the great marine transgression of the Mesozoic era appears to have begun about the same time. A return to subtropical humid conditions took place in the land area also. The Bay of Bengal was evidently formed before the close of the Jurassic period by a south-west encroachment of the Burmese sea. Volcanic eruptions took place on the land in the Rajmahal hills—

Assam range region about the beginning of the Cretaceous period. It is difficult to say precisely when the Madras mountain belt disappeared, but it is believed to have suffered immense erosion and finally sank beneath the invading Jurassic sea.

There came a pause at the close of the Mesozoic era followed by a vast outpouring of basaltic lavas on the Indian peninsula and by continued marine transgression in the Eocene period. These great movements marked the closing stages of the foundering of a land area between India and Madagascar and heralded the rise of the Himalaya and adjacent mountains. The period of maximum movement in the Tertiary era appears to have been in early Miocene times and regression of the bordering seas and uplift of the border ranges continued into the Pleistocene epoch. The climate of the Indian region was much cooler then and the Himalayan glaciers had attained their greatest spread then, although volcanic eruptions broke out locally in Upper Burma. Since the Pleistocene the tendency appears to have been towards a warmer climate, but crustal movements have continued. There have been local subsidences in some areas and small uplift in others and volcanoes have been active in the Bay of Bengal and on the borders of Baluchistan along the trend lines of the mountain arcs to within historic times.

Examining more closely the question of movement in the Indian region since Miocene and in relatively recent times, we find evidence of over-lapped displacements along thrust planes of over 20 miles in the Himalaya, and vertical dislocations involving a relative movement of the order of 10,000 feet in the Damodar valley coalfields. These are not isolated examples as there is abundant evidence of over-riding in the Assam region, in Burma and in the Punjab and North-West Frontier ranges, and there are now known to be many great faults which reveal the fractured condition of the Peninsula. It is true that the isolated mass of Parasnath gives clear evidence of fully 4,000 feet of erosion of the region around, and similar denudation is in progress at the headwaters of the Kistna and the deep valleys of the Himalaya, but these are relatively local not regional phenomena. They can hardly induce such changes of climate as that from frigid glacial to those of arid tropical within say a geological period. Definite change of position by displacement in surface position seems essential and such alterations of latitude must result from the relative movement of crustal over sub-crustal material—i.e. continental drift.

Seismologists support the idea of a concentric structure of the earth with an inner shell of weak material on a molten highly compressed metallic core and an outer shell of rock matter of great strength. All agree that the interior of the earth is highly heated and yet the surface is dependent for its warmth on solar radiation. Most geologists accept the view that the continental regions are largely constituted of granite and that the ocean beds are almost entirely of basalt and that this basalt also underlies the granite of the continents. Thus great isolated masses of granite rest on a bed of basalt, and it is a question whether this sub-continental or sub-crustal basalt is molten and thus permits the granitic rafts to float and drift on it. The evidence of seismograms is quite definite that at present there is no fluid sub-crustal region other than the very core of the earth nearly 2,000 miles below the surface. The sub-crustal layer is estimated at a depth of scarcely more than a dozen miles and perhaps not exceeding twice this amount.

As the equatorial surface of the earth has a speed of 1,000 miles an hour due to axial rotation alone, and is also subject to a gyratory oscillation, through an angle of 47°, which is completed once in 25,000 years, it would appear that the earth as a rotating body is not equally loaded. The unequal distribution of the continental masses suggests the inequalities of loading to be largely crustal and thus there are possibilities of resonance or vibrations being induced in the continental masses. These tendencies must presumably be aggravated by the tidal effects of the moon and

sun and thus there would appear to be forces at work in detaching the continents from their seating. Seismograms which show large oscillations of the L or surface waves as compared with the small oscillations due to the P and S waves furnish good evidence of the relatively shallow depth of the planes of movement which give rise to earthquakes. And notwithstanding these considerations mathematicians are implicit that the present forces are quite inadequate to cause the creep or drift of continents.

It is a common experience to find, in transporting cameras and surveying instruments, that nuts work loose upwards and often fall off during a long railway journey. Similarly a small disc of metal or wood may travel across the floor of a room which is subject to the vibrations of heavy machinery. Also it is certain that the rotation of monuments as a result of earthquake shocks is generally due to induced vibrations in eccentrically placed structures than to any curious character of the earthquake oscillations. Finally it is very difficult to believe that overriding to the extent of several miles on almost horizontal or up low inclined planes can seriously be attributed to direct pushing. Given sufficient time and periodical vibration and a free direction for travel it seems unnecessary to appeal to horizontal pushing to explain the final phenomena of over-folding and thrust faulting. If this is true in the case of superficial movements in the earth's crust, which is itself a veneer to the earth itself, there appear to be possibilities of crustal creep or drift notwithstanding the mathematical objections.

The viscosity of the sub-crustal layer is perhaps the most rational objection to continental drift where the determination of a measurable rate of movement is desired. It seems impossible to ascertain any definite changes of latitude or of longitude free of error of observation as the movements must be exceedingly slow if there is no fluid sub-crustal layer for horizontal slipping. The question is whether the present solid condition of the sub-crust is permanent or whether there is any direct evidence to show the possibility of its periodic melting. This probability of periodic melting is so well-established that it led Professor Joly to develop his splendid hypothesis to explain the periodicity of volcanic eruptions—roughly every 40 million years—and thus account for the periodic regional earth (crustal) movements. He invoked the heat generated within the crust from radio-active disintegration as the cause of the melting. He showed that given a certain rate of internal heat generation periodic melting of the sub-crustal layer must occur and this would explain most of the facts of crustal movement. Such an hypothesis would also permit of continental drift. Unfortunately the available data shows that the radio-active elements are less than Professor Joly assumed and that the heat generated on the smaller proportion works out to be insufficient. Here again we are dealing with calculations on data which may be found in need of modification.

Investigations in regard to the Stratosphere and Ionosphere have revealed the Sun to be the source of supply of electro-magnetic energy in a new and an astonishing degree. It is now suggested that not only does Sun-spot activity affect the earth's magnetic field but that terrestrial magnetism is probably induced by the direct results of solar radiation. These radiations constitute an electric field through which the earth travels and rotates at high speed and that in so doing it behaves like the motor of an induction motor and that eddy currents are induced in its shell below the rocky crust. The magnetic field of these induced currents presumably satisfies the conditions of the earth's magnetic field and thus solves the riddle of terrestrial magnetism. If these ideas are true and electric currents are induced in some sub-crustal zone it seems logical to conclude that considerable heat must also be generated—in the same manner as is involved in the principle of an electric resistance furnace. There might thus be generated the heat necessary for re-establishing Professor Joly's hypothesis and so allowing of the possibility of periodic

melting in the sub-crustal layer, and thus rendering the theory of continental drift acceptable to those who still dislike it.

The present position is one of stalemate between those who demand extremely delicate measurements under what are evidently unfavourable conditions at present, and those who have been carried away by the far-reaching possibilities of continental drift without giving attention to many of its limitations. From a geological point of view the general evidence appears to favour the travel of the granitic continental masses irregularly across the surface of the earth, the crust of which seems to be unequally loaded. There seems to have been a large southern continent, Gondwanaland, in Palæozoic times which broke up and drifted northward as, among other fragments, India and Africa towards and over the equator. There also appears to have been a northern continent, Angaraland, which drifted south-westward as Europe-Asia against the northern ends of India and Africa. While shearing has split the continent of Africa from the Zambesi to Akba the marine geosynclinal between Asia and India suffered intense compression which resulted in the upheaval of the Himalaya and other mountain chains. Different movements have naturally occurred due to the opposing continental masses—Asia and India meeting obliquely. The Indian peninsula has been severely fractured in various directions by the thrust from the Asiatic mass, and local irregularities such as the rise of the Assam range and the mountains of Burma and the North-Western region of India have appeared.

In conclusion it may be added that should it be possible to accept some estimate for periodic melting of the sub-crust and thus arrive at a regular periodicity in regard to volcanic eruptions, followed regularly by earth-movements in regard to the land, and some order in the climatic changes in the continental areas of the earth, it may become possible to work backwards and trace stage by stage the direction of drift of a particular mass. It may thus be possible to establish its origin and relationships during past geological epochs. Unlike icebergs the granitic rafts of continents do not evidently entirely disappear, and although they fracture, drift apart, crush and over-ride and, perhaps, get squeezed down and partially melted, something still remains. The fossil evidence in the sediments associated with these continental areas will give clues to the climates of past ages which may prove valuable in fixing their position, not only in regard to latitude and geological time but also for longitude. Thus the whole history of the various parts of the earth's crust may possibly be deciphered and yield unsuspected secrets of value for the benefit of mankind.

A. K. Dey (*Calcutta*).—The distribution of marine organisms on the lines which guide the correlation of geological formations has an important bearing on all questions connected with the past geography of the earth. It will be seen from the following account of distribution of marine organisms that a direct communication existed between the Mediterranean Sea and the Indian Ocean by way of the Arabian Sea in the late Jurassic and Cretaceous times.

The Patcham, Chari, Katrol and lower Umia groups of Cutch comprising the Middle and Upper Jurassic formations contain abundant European species.

The Mazar Drik fauna of Baluchistan is closely allied to the fauna of *macrocephalus* age in Cutch. The identification of *Macrocephalites madagascariensis*,[1] Lemoine, in the ammonites of Mazar Drik shows that Madagascar was not a separate zoological province from Baluchistan during Jurassic times.

The fossils from the Jurassic limestone of South Arabia contain species which are either identical with or closely related to species found

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[1] Spath, L. F., Revision of the Jurassic fauna of Cutch, *Pal. Ind.*, N.S., 9, Mem. No. 2, Pt. 6, p. 808, (1933).

in the Jurassic beds of the Himalayan region, Cutch, Abyssinia, Somaliland, Tanganyika, Mombasa and Madagascar.

The resemblance of the Jurassic faunas of Cutch to those of Mombasa is known through the researches of Spath and Weir.[1] The discovery of *Sindeites sindensis*, Spath in the Callovian fauna of Mombasa is of interest because the only other localities from where this species has been recorded besides Cutch are Rajputana and Madagascar.

According to Tornquist, the Mtaru fauna of Tanganyika, containing *Macrocephalites holcostephanoides*, closely agrees with that of the Dhosa oolite of Cutch. Spath [2] has accepted this view of Tornquist. *Hildoglochiceras kobelli* (Oppel), known from Cutch, the Central Himalayan region, and Madagascar also occurs in Tendaguru of Tanganyika.

There is distinct similarity between the Jurassic faunas of Cutch and those of Madagascar. This similarity has recently been reviewed by Spath [3] and according to him ' the Indian Ocean, in Upper Jurassic times, differed from its modern representative chiefly in being open to the Tethys in the north '. Spath [4] has also shown the resemblance of Upper Jurassic Faunas of Cutch to those of the Malay region. Uhlig, in 1910, indicated the direct communication between the Southern and Equatorial seas during the Upper Umia and Uitenhage times. Pavlow studied an *Olcostephanus* from the Uitenhage beds of South Africa which could hardly be separated from *Olcostephanus schenki*, Oppel, from the Spiti shales. The resemblance of the Neocomian fauna of Baluchistan to that of Madagascar has been recognized through *Duvalia dilatata*, Blainv.

The upper part of the Umia group of Cutch which is of Lower Cretaceous age has yielded several species *Trigonia* found in the Lower Cretaceous beds of East Africa and South Africa (Uitenhage beds); species closely allied to *Trigonia longa* and *Pycnodonta* of the Umia of Cutch and Uitenhage of South Africa have been found in the Lower Cretaceous beds of Madagascar.

The Lower Cretaceous beds of Tanganyika show a mixture of South African and European species indicating direct communication between the Mediterranean and the Southern seas. The Umia forms of *Trigonia* referred to the Uitenhage species are represented in the Lower Cretaceous fauna of Tripetty beds in Madras. It is of interest to note that some of the fauna of Cutch and of the Uitenhage of South Africa is represented in the Lower Cretaceous beds of Bolivia, Chile and Argentine showing a direct sea route in the south. While the occurrence of *Crioceras australe*, Waagen, an Australian species in the Cretaceous beds of Cutch and Madagascar and of *Douvilleiceras martini* an European species in the Lower Cretaceous deposits of Cutch and Mozambique channel suggest sea communication between Cutch, Portuguese East Africa, Madagascar and Australia.

The Cretaceous fauna of South India gives a clear conception of the palæogeographic condition of the Indo-Pacific region of that period. Neumayr has selected this fauna as the type of the Cretaceous rocks of the Pacific. Indeed the distribution of some species of this area is extraordinarily wide. They have been recorded from such widely separated parts of the Indo-Pacific region as Natal, Madagascar, Borneo, Vancouver, Assam, Baluchistan and Iran. The species therefore constitute a huge

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[1] Spath, L. F., ' Jurassic Ammonites of Mombasa '; and Weir, John, ' Mesozoic Brachiopoda and Mullusca from Mombasa ', *Monograph of Geol. Dept., Hunterian Museum, Glasgow University*, (1930).

Spath, L. F., Revision of the Jurassic Cephalopod fauna of Cutch, *Pal. Ind.*, N.S., 9, Mem. No. 2, Pt. 6, pp. 815–818, (1933).

[2] Spath, L. F., ' Revision of the Jurassic Cephalopod fauna of Cutch ', *Pal. Ind.*, N.S., 9, Mem. No. 2, Pt. 6, p. 819, (1933).

[3] Spath, L. F., *ibid.*, pp. 821–825.

[4] Spath, L. F., *ibid.*, pp. 825-826.

marine province in which there was a free intercommunication between its different parts.

It is of interest to note that the fauna of South India (Pondicherry-Trichinopoly-Aryialur) like that of Natal contains a number of Central European elements. The remarkable similarity which the fauna of South India presents to the fauna of the same age in the Central Europe is not merely due to the presence of identical and closely allied forms which it contains but also by the fact that the succession of individual forms in South India also corresponds very closely with that found in the Central Europe.[1]

The age of the Cretaceous beds of South India (Pondicherry-Trichinopoly-Ariyalur area) has been fixed by means of European species found in the fauna. Now the question arises as to the connection between the Cretaceous sea of Southern India and that of Central Europe. The theory of land-bridges between India and South Africa received additional evidence in its support from the researches of Duncan and Noetling. Duncan showed that the echinoderm fauna of the Bagh beds in the Narbada valley is very closely allied to the echinoderm fauna of the Cretaceous beds of the Mediterranean region, North Africa and Syria, while it is quite distinct from that of the Utatur group of the Trichinopoly area which is however of the same age. Noetling's study of the Cretaceous echinoderm of Dungham stage of Baluchistan has proved the entire dissimilarity of the fauna to that of the Ariyalur stage of Southern India. Kossmat, therefore, suggested the possibility of communication between the Mediterranean province and South India by way of Angola and Elobi islands on the west coast of Africa. But this is a very indirect route and the material in its support consists of a few cosmopolitan forms. Spath does not think that there was any direct connection between the Indo-Malgascan province and the West Coast of Africa via the Cape. According to him interchange of fauna has taken place by way of the Mediterranean.[2]

The Cretaceous fauna of the Khasi Hills in Assam has nothing in common with that of the Tibetan region. On the other hand, there are striking affinities between the fossils of South India on the one hand and those of Baluchistan on the other. This has been regarded as evidence of existence of a land barrier between Tibet and Assam in late Cretaceous times. This belief is supported by the presence of coal seams, suggesting a shore line of Upper Cretaceous age in the Garo Hills of Assam.[3]

It is of considerable interest to know that the Cretaceous fauna of Assam has 12 species in common with that of the Iran-Baluchistan region. According to Spengler the relationship between the Upper Senonian faunas of South India (Ariyalur), Assam and Baluchistan 'shows clearly that the fauna of Assam occupies a medium position between that of South India and that of Baluchistan'. This fact cannot be passed over lightly for it has a bearing on the existence or non-existence of sea connection between Assam and Baluchistan via the Indo-Gangetic trough in Cretaceous times. According to the principle of migration of geosynclines propounded by Grabau, the site of the Indo-Gangetic plains and that of the late Tertiary deposits was an elevated landmass until the close of the Eocene, supplying materials for the deposits of the Himalayan geosyncline.[4]

The difficulty that confronts us now is the question of the diffusion of a common marine fauna in widely separated parts of the Indo-Pacific

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[1] Kossmat, F., 'On the Importance of the Cretaceous Rocks of Southern India in Estimating the Geographical Conditions during later Cretaceous times'. *Rec. Geol. Surv. Ind.*, XXVIII, 2, (1895).

[2] L. F. Spath, 'Cretaceous Ammonites from Angola', *Trans. Roy. Soc., Edin.*, 1922, p. 156.

[3] C. S. Fox, 'Cretaceous Cephalopods', *Rec. Geol. Surv. Ind.*, LXIII, p. 186, (1930).

[4] Grabau, A. H., 'Stratigraphy of China', II, p. 256, 1928.

regions. The effectiveness of a land-bridge between India and South Africa to explain the difference of the echinoderm fauna between the Baghs and the Utatur beds or between the Sphenodiscus beds of Baluchistan and the Ariyalur stage of South India may, therefore, be doubted.

The marked distinction of the Bagh bed fauna of the Narbada valley rom the Utatur beds of South India has been much diminished by the collection of fossils made by Mr. P. N. Mukherjee from the Jhabua-Alirajpur area. A few South Indian forms have now been added to the Bagh fauna, among which mention may be made of *Protocardium pondicheriense*, d'orb, *Cardium* (*Trachycardium*) *incomptum*, Sow. and *Cytheria* (*Callista*) *cf. sculpturata*, Stol., while two more species bear closest affinities to *Grotriana jugosa* Forb. and *Gouldia planissima* Forb. from the Cretaceous beds of Pondicherry.

With regard to the apparent difference between the echinoderm fauna of the Sphenodiscus beds of Baluchistan and the Ariyalur stage of South India, Kossmat writes 'unfortunately the proofs deducible from the echinoderm fauna of Baluchistan are considerably weakened by the fact that in South India the echinoderms occur in the Upper Senonian Ariyalur beds, whilst in the overlying faunistically very sharply separated Niniyur beds (Danian) they are up to the present time wanting; it is therefore to be expected that on account of the difference in age the echinoderm fauna of the Danian of Baluchistan must be different from that of the Upper Senonian Ariyalur stage'.

Occurrence of *Volutilithes latisepta*, Stol., a typical South Indian species in the *Maëstrichtian* beds of the Mari Hills in Baluchistan and *Strombus* (*Pugnellus*) *Crassicostatus*, Noetl, an Upper Cretaceous form of Baluchistan in the corresponding Cretaceous beds of Madagascar is of interest showing direct connection between Baluchistan, Madagascar and South India. According to Noetling *Strombus* (*Pugnellus*) *crassicostatus* is very closely related to *Pugnellus uncatus* Forbes from South India.

The Cenomanian fauna of Kabir-Kush in Luristan contain several species that are found in the Cretaceous beds of South India. The extension of the Ariyalur fauna of South India into the Mediterranean region is shown in the Mæstrichtian beds exposed on the Elbruz, near Zirab on the Talar. The fossils in these beds show an association of typical European species with those that have pronounced South Indian affinities.[1]

The distribution of marine fauna in the Middle and Upper Mesozoic seas of the East African continent and India, therefore, provides a clear evidence of free inter-communication between the Eastern Tethys and the Indian ocean across the present day Arabian Sea. This conclusion supports Wegener. For according to Wegener, the Arabian Sea has been created since the Mesozoic time by the drifting of India towards north-east. As there is not sufficient palæontological evidence to prove the existence of the Arabian Sea during the Palæozoic time, one is likely to be carried away with Wegener's theory, for it solves many difficult questions about the distribution of life, glaciation, mountain-building, etc.

According to Grabau,[2] India was joined to the Arabia-African continent via Iran through most of the Palæozoic time, and during the Trias and Lower Jurassic periods. Subsequently they were separated, and again joined during the Tertiary. He thinks that during such intervals of land connections, inter-migrations of flora and terrestrial animals took place by this route. Those who believe in the permanency of land and sea will probably agree with Grabau and discard the necessity of interposing a purely hypothetical land-bridge across the Indian ocean. Otherwise a few more islands with temporary isthmian links between them

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1 Grabau, A. W., 'Stratigraphy of China,' II, pp. 575–576.
2 Grabau, A. W., 'Stratigraphy of China,' II, pp. 252–254, (1928).

in the shallow belt extending from the Maldive Islands to Madagascar and Africa via Chagos and Seychelles Islands are only required to account for the migration of flora and terrestrial fauna.

In the discussion that followed Dr. Hora explained that though his studies did not support or refute Wegener's hypothesis they postulated a continuous land connection between India and Africa as late as the Middle Tertiary so as to permit the migration of the modern bony fishes of the Oriental Region to Africa. According to Wegener's theory India and Africa began to drift apart in the Jurassic period, but this contention is not borne out by the distribution of fishes. If the continuity of land during the Tertiary age is conceded, then it seems more probable that the formation of the Arabian Sea must have resulted from a subsidence of land connections between India and Africa during late Tertiary times rather than by the drifting apart of the two continents in the manner and time envisaged by Wegener.

The PRESIDENT, in bringing the discussion to a close, said that undoubtedly Prof. Sahni had brought forward strong arguments in favour of continental movement of some kind, and moreover it agreed with the movement that seemed to be required to account for the immense amount of compression that had produced the Himalayas and associated ranges. Mr. Evans had given an actual estimate of at least 400 miles for the contraction that had taken place on either side of the Assam Valley in late Tertiary times, and though this was not the amount required by Wegener, it indicated very considerable movement.

Prof. Rama Rao, in drawing attention to the geological evidence adduced by various writers as to the dissimilarity of the geological structure on either side of the Atlantic, had ignored the much more important researches of A. L. du Toit, who had shown that the similarity between South America and Africa, if the two continents were brought to within about 250–500 miles of each other, was so striking as to be beyond the possibility of coincidence.[1]

It seemed likely that in the formation of the Himalayas there had been a movement northwards of India underthrusting Asia, rather than the reverse, and this was in agreement with the direction of movement postulated by Wegener. At the same time it would be very rash, with our present knowledge, to conclude with Wegener that India was once adjacent to South Africa and Madagascar. Two rival theories had to be considered, continental movement or the sinking of land-bridges. As regards the formation of the Arabian Sea, the speaker was inclined to think that both these types of movement had been operative, and it was probable that, as in the case of so many rival theories, the true solution would be found to lie in between. Whether or not this discussion had thrown much light on Wegener's hypothesis, it had certainly brought out a number of interesting facts, and the discussion had been very worth while.

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[1] du Toit, A. L., 'A geological comparison of South America with South Africa', *Carn. Inst. Wash.*, (1927).

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LIST OF MEMBERS, TWENTY-FOURTH INDIAN SCIENCE CONGRESS.

ORDINARY MEMBERS, 1936-1937.

As at the close of July 15th, 1936 ; Rule 4.

The names of Life Members are marked with an asterisk.

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OFFICIAL.

A. RULES AND REGULATIONS, INDIAN SCIENCE CONGRESS ASSOCIATION.

A.1. In view of the steady growth in all directions of the Indian Science Congress Association and of the opinions expressed by some members of the Congress that a better organisation of the scientific work could be effected it was considered desirable to ascertain what further steps regarding the running of the Congress might be taken with a view to improving its scientific work. It was felt that such alterations and additions to the Rules, as may be decided upon, should be effected before the Silver Jubilee Session. Accordingly in September, 1935, a circular letter was issued by the General Secretary to Past General and Sectional Presidents of the Association requesting them to make suggestions. A summary of the suggestions received together with a note by the General Secretary was circulated in December, 1935, to members of the Council. The Council at its meeting on the 2nd January, 1936, in the Daly College, Indore, appointed a sub-committee to go into the matter and to report to the Council.

A.2. The report submitted by the sub-committee which was adopted by the Council at its meeting held in Calcutta on the 17th November and circulated to members of the General Committee is printed below :

REPORT OF SUB-COMMITTEE APPOINTED BY THE COUNCIL

Preparation, Acceptance, Reading and Publication of Abstracts of Papers.

The existing rules regarding the acceptance and reading of papers and the publication of abstracts should be uniformly enforced. The papers under each subject should be arranged into *recognised groups*. The authors, whose papers have been accepted for reading at the meeting, should be previously informed by the Sectional President and the time which would be allotted to the reading of the paper should also be intimated. In case of a number of papers from the same author, either singly or jointly, the author should specify only one which he would prefer to read at the meeting. When all the papers on a related topic have been read, a joint discussion on them should be invited by the Sectional President. The time limits for reading a paper and for those taking part in the discussion should be announced by the Sectional President at the meeting. Only persons present should have the first option of reading papers. If time is available papers not mentioned above may be read at the discretion of the Sectional President.

In the circular of instructions sent to the Sectional Presidents, their attention should be drawn to the desirability of neatness in presentation of the papers and abstracts and they should advise authors, wherever considered necessary, as to the changes considered desirable with a view to improve its interest, e.g., the preparation of lantern slides, charts, graphs and similar matters. A summary of each paper, preferably cyclostyle copies, should be available wherever possible for distribution at the meeting. If this is not possible the authors should at least come prepared with a fuller summary of their papers than given in the abstracts for reading at the meeting. Two copies of such summaries, one for the Sectional President and the other for the Sectional Recorder, should

always be available. Abstract of a paper which has been accepted and printed before the meeting should not in future be deleted in the final Proceedings as the existing procedure entails heavy expenditure and unduly delays the publication of the Proceedings. Such Abstracts should be published in advance in one volume. It is therefore necessary that the printed abstracts circulated before the Session should only contain such materials as have been fully refereed and scrutinised by the President as provided under Rule 30(*c*) and which stands in the names of those persons who have been informed that their papers have been accepted for reading. No abstracts will however be included in this volume from persons who have not already paid their membership subscription. The necessary check will be exercised by the Managing Secretary who would forthwith send information of such omissions to the Sectional President concerned so that the author gets a chance to be a member of the Association. Abstracts of papers from authors whose subscription is received after this notice will be published in the supplementary volume (*vide* section under printing of Proceedings). References to literature in abstracts should be avoided as far as possible. There should be a uniform system of abbreviation of references to journals and the authors should be asked to conform to it. Sectional Committees should be requested to draw up a list of abbreviations.

A SECTIONAL CORRESPONDENT should be appointed for each Section, who should be resident at headquarters (Calcutta), for assisting the Sectional Presidents in such matters, as the refereeing of papers, verification of references, etc., when called upon to do so by the Sectional President. He should also correct the proofs of publications relating to his section when required to do so by the General Secretary.

The Sectional Recorders shall be responsible for maintaining a proper record of the proceedings of the meetings of the Sectional Committees and of the Section. The proceedings of the Sectional Committees shall be recorded in a minute book.

The Sectional Recorders should be instructed to obtain the summary of the observations of any person taking part in a discussion and to draw up a short report, in consultation with the Sectional Presidents, of the proceedings of the Sections and of the Sectional Committees.

Time of Meetings of Sections, Excursions and Symposia.

The Sub-committee propose that the time for the meetings of the Sections should be altered to 9-30 A.M. to 12-30 P.M. One afternoon should be set apart in the programme for the General Committee meeting, one for Sectional Excursions, one for the meeting of Learned Societies, one or two for Symposia. The time for these Afternoon Meetings should be fixed between 2 to 4-30 or 5 P.M. according to circumstances. On the date fixed for the excursions there should be no Social Engagements. It should be possible to arrange for about 4 or 5 Symposia each Session. One or two Symposia may be held in the morning if considered desirable. Symposia concerning more than two Sections may be held on a separate date in one afternoon.

Organisation of Sections.

In addition to the SECTIONAL CORRESPONDENT there should be a LOCAL SECTIONAL SECRETARY for each Section who will be responsible for all local arrangements regarding the Section including excursions.

No new Section should be opened for sometime to come but Sub-sections should be created as considered desirable.

The Sections shall meet as a whole on the first day and then separate into Sub-sections if considered necessary. A separate chairman may be

appointed by the Sectional President in consultation with the Sectional Committee to preside over each Sub-section. All papers grouped under such Sub-sections should be read and discussed at the meetings of the Sub-sections.

The functions of the Sectional Secretaries, the Sectional Recorders and the Local Sectional Secretaries should be clearly stated.

Each Sectional Committee should ordinarily meet on the opening day of the Session and also as far as possible before each day's meeting. They should always consider the scientific work of the Session and make suggestions whenever considered necessary.

Nominations by absent members for election of Sectional and other officers of the Congress cannot be taken as votes but shall be considered and recorded in the Proceedings of the Section. The complete record regarding this matter shall be forwarded to the Executive Committee along with the Sectional Committee's nominations.

Printing of Proceedings.

The Sub-committee consider that it is possible to minimise the delay and the cost of printing of Proceedings provided the following suggestions are accepted.

Corrections in the addresses of the General and Sectional Presidents should not be admitted after they have been once printed, as adequate notice for preparing the address and opportunities for corrections of proofs are offered. This will also enable the authors to distribute their addresses without delay. The Presidential addresses will be distributed to members present during the Session and to absentee members by post immediately after the Session. The printed addresses will also be available for purchase. The Presidential addresses should be printed separately in advance as volume II, and those abstracts which have been accepted for reading as proposed above should be published as volume I and distributed to members before the Session. The list of officers, the Proceedings of the Opening meeting without the address of the General President together with the material printed in the Proceedings under the heads ' General ' and ' Official ' should be printed together as volume III immediately after the Session.

The discussions, the list of members and the Index should be printed together as volume IV. In exceptional circumstances abstracts received after the printing of volume I if specially recommended by the Sectional Committee may be printed in this volume.

General.

The Sub-committee consider that Social Engagements and General Excursions as usually arranged will not interfere with the scientific work of the Congress if the above proposals are accepted.

Circular letters to Governments, Universities and other Institutes should be sent with a view to ensure the attendance of prominent scientific men under their employ.

There should be a uniform and permanent badge providing space for insertion of the typed name of each member of the Congress Association attending a Session and distinguishing the different categories of officers.

A.3. Draft Rules and Regulations framed by the Council to give effect to the report, were next approved by the Executive Committee, and circulated to the members of the General Committee on November 30th, 1936. The Rules and Regulations as adopted by the General Committee at its meeting held on the 5th January, 1937, at 2 P.M. in the Address Hall, Osmania University Buildings, Hyderabad, Deccan, are printed on the next page.

RULES AND REGULATIONS

Indian Science Congress Association

RULES

1. The name of the Association shall be the Indian Science Congress Association, and its object shall be the advancement of Science in India by the annual holding of a Congress and the doing of all such things as are incidental or conducive to the above object, including—

(*a*) the holding and management of funds and property ;
(*b*) the acquisition of rights and privileges necessary or convenient for the object of the Association ;
(*c*) the management, development, improvement, disposal, and sale of all and any parts of the property of the Association.

2. The Association shall consist of Ordinary Members and Session Members.
3. Ordinary Members of the Association shall have the right to contribute papers for reading at the Session of the Congress, to receive free of charge all publications issued by the Association, and to fill any office in the Association on being duly elected thereto.
4. The annual subscription of Ordinary Members shall be Rs. 10. The subscription shall become due on the 1st February of each year, and shall only be effective as a payment for Ordinary membership subscription if received before the 15th July of the year.
5. Any Ordinary Member may compound for the payment of all future annual subscriptions by the payment in a single sum of Rs. 150.
6. There shall be three classes of Session Members :—

(*a*) Full Session Members—subscription Rs. 10 per Session.
(*b*) Associate Session Members—subscription Rs. 5 per Session.
(*c*) Student Session Members—subscription Rs. 2 per Session.

7. Full Session Members shall have the right to contribute papers for reading at the Session of the Congress, and to receive free of charge all publications issued by the Association relating to the Session of the Congress of which they are Members.

Associate and Student Session Members shall have the right to submit papers for reading at the Session of the Congress of which they are Members provided such papers be communicated through an Ordinary Member of the Association.

A Student Member shall before admission be duly certified by the head of his Institution to be a *bona fide* student.

8. The official year of the Association shall commence from the 1st of February.
9. There shall be Officers of the Association consisting of the Members of the Executive Committee and Presidents and Recorders of Sections.
10. Only Ordinary Members shall hold office in the Association.
11. The term of office of all Officers of the Association except the President shall commence from the beginning of the official year and shall extend until the assumption of office by their successors appointed in accordance with the provisions of these Rules. The President shall assume office on the opening day of the Annual Congress following the

one at which he is appointed, and shall continue to hold office until the assumption of office by his successor.

12. There shall be an Executive Committee which shall carry on the administrative work of the Association and submit such questions as it thinks desirable to a General Committee at its Annual Meeting during the Session of the Congress or at a Special Meeting of which due notice shall have been given.

13. The Executive Committee shall consist of the President, the President-elect for the following year, the two General Secretaries, the Treasurer (who shall be the Treasurer of the Royal Asiatic Society of Bengal for the time being), the Managing Secretary (who shall be the General Secretary of the Royal Asiatic Society of Bengal for the time being), and five Ordinary Members elected by the General Committee. For the purpose of this election any Ordinary Member may propose the name of an Ordinary Member for election to the Executive Committee. Such proposal must be seconded by another Ordinary Member and must reach the General Secretary before the 15th September. The Executive Committee shall circulate these names, together with such other names, not exceeding three, as it may suggest, to all Ordinary Members for election by ballot. The ballot papers will be scrutinised by the President and the General Secretaries, and the results of the ballot will be announced at the meeting of the General Committee.

The Executive Committee shall co-opt as Members at least one and not more than two Local Secretaries for the ensuing Session of the Congress.

14. The Executive Committee shall have full power to transact all business in cases of emergency, notwithstanding any limitations hereinafter laid down, and to deal with all matters not otherwise provided for in these Rules, including the making of such Regulations as may appear conducive to the good administration of the Association and the attainment of its object; provided always that such Regulations be not inconsistent with anything contained in these Rules, that they be reported for the information of the next meeting of the General Committee, and that they be subject to rescission or alteration by the Executive Committee or by any meeting of the General Committee.

15. There shall be a General Committee which shall consist of all Ordinary Members of the Association.

16. The General Committee shall meet at least once during each Session of the Congress preferably in the middle of the Session.

17. There shall be a Council which shall consist of all Members of the Executive Committee, and all such Ordinary Members of the Association as have held office as President, General Secretary, Treasurer, or Managing Secretary of the Association, the Sectional Presidents for the ensuing Session, and in addition five Ordinary Members of the Association elected by the General Committee. For the purpose of this election any Ordinary Member may propose the name of an Ordinary Member for election to the Council. Such proposal must be seconded by another Ordinary Member and must reach the General Secretary before the 15th September. The Executive Committee shall circulate these names, together with such other names, not exceeding three, as it may suggest, to all Ordinary Members for election by ballot. The ballot papers will be scrutinised by the President and the General Secretaries, and the results of the ballot will be announced at the meeting of the General Committee.

18. The function of the Council shall be to act as a body of advisers to be consulted by the Executive Committee on important questions of policy or scientific import.

19. There shall be a President who shall be nominated by the Executive Committee and whose nomination shall be submitted to the General Committee at its Annual Meeting during the Session of the Congress for confirmation.

20. There shall be two General Secretaries who shall be nominated by the Executive Committee and whose nomination shall be submitted to the General Committee at its Annual Meeting during the Session of the Congress for confirmation.

21. The term of office of each General Secretary shall be for a period of five years following the confirmation of his appointment and he shall be eligible for re-appointment.

22. In the event of a vacancy amongst the General Secretaries occurring between two Sessions of the Congress the Executive Committee shall have power to appoint a General Secretary for the period up to the termination of the next Session of the Congress.

23. There shall be a Local Secretary or Local Secretaries for each Session of the Congress who shall be appointed by the Executive Committee.

24. There shall be a Local Committee for each Session of the Congress which shall be appointed by the Executive Committee.

25. The Local Secretary, or Secretaries, and the Local Committee shall jointly, on behalf of and in consultation with the Executive Committee, make all necessary arrangements for the holding of the Session of the Congress.

26. For the purpose of scientific deliberation during the Session of the Congress there shall be such Sections corresponding to different branches of science as may from time to time be constituted by the General Committee on the recommendation of the Executive Committee. It shall be competent for any section after the first day's meeting to hold its scientific meetings in Sub-sections for the purpose of dealing separately with different groups of papers submitted to that Section. A separate chairman may be appointed by the Sectional President in consultation with the Sectional Committee to preside over each Sub-section.

27. There shall be in each Section a President and a Recorder who shall be appointed by the Executive Committee. In addition there shall be a Sectional Correspondent and a Local Sectional Secretary who shall be appointed by the Executive Committee.

28. In each Section there shall be Sectional Officers, namely, a President, a Recorder, a Sectional Correspondent, and a Local Sectional Secretary. The President and the Recorder shall be the chief executive officers of the Section. They shall have power to act on behalf of the Sectional Committee in any matter of urgency which cannot be brought before the Sectional Committee for consideration, and they shall report such action to the Sectional Committee at its next meeting.

The work of each Section shall be conducted by a Sectional Committee which shall be constituted as follows:—

(*a*) Sectional Officers.
(*b*) All Ordinary Members of the Association who have been President or Recorder of the Section.
(*c*) Two Ordinary Members of the Association elected by the General Committee at its Annual Meeting during the Session of the Congress.

The Sectional President shall preside over all meetings of the Section and of the Sectional Committee. He shall be the convener of the meetings of the Sectional Committee. His ruling shall be final on all points of order that may arise.

The Sectional Recorder shall act as the Secretary of the Sectional Committee, and shall maintain a proper record of the proceedings of the Sectional Committee and of the Section in a book provided for the purpose. He shall be responsible for the punctual transmission to the General Secretary of the recommendations adopted by the Sectional Committee, and of resolutions adopted by the Section.

The Sectional Correspondent shall be resident at the headquarters of the Association, and shall be responsible for preparing for the press

the material relating to his Section, according to the instructions of the Sectional President.

The Local Sectional Secretary shall be resident in the locality where the Annual Session is held, and shall be responsible for all local arrangements for the work of his Section, and for arranging the Sectional excursions in consultation with the Local Secretaries.

29. The Sectional Committee shall meet on the opening day of each Session of the Congress, and daily thereafter during the Session before the meeting of the Section unless otherwise determined at a meeting of the Sectional Committee.

In the absence of the Sectional President from any of its meetings the most senior member of the Sectional Committee present shall take the chair.

In their meeting on the opening day they shall :—

(*a*) nominate a Sectional President and a Sectional Recorder for the ensuing year for the consideration of the Executive Committee ;
(*b*) determine the detailed arrangements for the Sectional meetings ;
(*c*) select the papers to be read and discussed ;

and in their meetings during the Session they shall also :—

(*d*) nominate a Sectional Correspondent and a Local Sectional Secretary for the ensuing year for the consideration of the Executive Committee ;
(*e*) determine the contents of the Sectional record in the Proceedings in accordance with Rule 30 (*e*) ;
(*f*) consider means of improving the scientific work of the Section, and make suggestions to the Executive Committee whenever considered necessary.

Nominations by absent members of the Sectional Committee for the election of the Sectional President and Sectional Recorder for the ensuing year shall not be regarded as votes. The suggestions, however, shall be considered and recorded in the minutes of the meeting, which shall be forwarded to the Executive Committee along with the Sectional Committee's nominations.

30. (*a*) Any paper submitted for reading at the Session of the Congress shall be forwarded to the President of the Section concerned so as to reach him not later than a date to be fixed from time to time by the Executive Committee.

(*b*) Any paper submitted for reading at the Session of the Congress shall be accompanied by an abstract in triplicate.

(*c*) Any paper submitted for reading at the Session of the Congress shall be refereed by the Sectional President or by some person or persons appointed by him. Decisions with regard to acceptance or rejection of any paper shall be final and all reports confidential.

(*d*) No paper published elsewhere shall be accepted.

(*e*) Only abstracts of papers received by the President before the date fixed by the Executive Committee in accordance with Rule 30 (*a*) shall be printed in Part III of the Proceedings. In exceptional circumstances abstracts of papers received after that date and read before the Section, if specially recommended by the Sectional Committee, may be printed in Part IV.

31. The Proceedings of the Indian Science Congress Association shall be published in one volume in four separate parts, as follows :—

I. To contain the list of officers, the proceedings of the opening meeting (except the General Presidential Address) and all official matter.
II. To contain the Presidential Addresses. To be distributed to those present at the meeting after the addresses have been

delivered, and to absent Ordinary and Full Session Members by post after the meeting.

III. To contain the abstracts of papers to be read before the Sections which are received before the date fixed by the Executive Committee. No abstracts shall be included in this volume from authors who have not already enrolled themselves as Members of the Association. To be distributed in advance of the Meeting to all Members of the Association.

IV. To contain the discussions, late abstracts accepted in accordance with Rule 30 (*e*), the list of members and the index.

32. The following procedure shall be observed for the making of any addition to or alteration in the Rules of the Association :—

(i) Proposals for additions to and alterations in the existing Rules may be placed at any time before the General Commitee by the Executive Committee.

(ii) (*a*) Proposals for additions to and alterations in the existing Rules by any Ordinary Member of the Association shall be sent to one of the General Secretaries so as to reach him two full months before the meeting of the General Committee in which they are to be moved.

(*b*) One of the General Secretaries shall circulate such proposals to all Ordinary Members of the Association at least one full month before the meeting of the General Committee.

(*c*) Any amendments to the proposals shall be sent by any Ordinary Member of the Association to one of the General Secretaries so as to reach him at least a fortnight before the meeting of the General Committee.

(*d*) The proposals together with any amendments shall be brought up before the meeting of the General Committee at its Annual Meeting during the Session of the Congress together with any remarks of the Executive Committee and declared carried if accepted by a two-thirds' majority of the constituent Members present and voting at the meeting.

(Adopted the 5th January, 1931.
Revised the 5th January, 1935,
the 6th January, 1936 and
the 5th January, 1937.)

REGULATIONS

I. Sectional Officers.

(1) The President delivers a Presidential address which should not take more than one hour to deliver. The manuscript of the address, ready for the press, should be sent to the General Secretary before the 15th November. It should be accompanied by 12 copies of a short popular summary (about 500 words) for issue to the lay press. The time and date of the delivery of the President's address will be communicated before the meeting of the Congress. No two Presidential addresses will be delivered at the same time.

(2) The President shall be entitled to receive 30 copies of his address without charge, and additional copies at the cost of reproduction.

(3) Railway fares, postage, clerical, or other expenses incurred by the Sectional Presidents will not be paid by the Association.

(4) The following procedure is adopted for the collection of papers for the Sections :—

About the middle of April a number of copies of a printed circular will be forwarded to the President of each Section who may arrange

to send these to workers in that branch of science with which his Section is concerned, requesting them to contribute papers for reading before the next meeting of the Congress.

The circular will contain a clause inviting such workers as are not yet Ordinary Members of the Association to join as such. Particular note should be taken of the fact that no new Ordinary Members are enrolled after the 15th July of the year.

In the case of joint papers, each author must be a Member of some category.

(5) The President referees, either in person or by proxy, the papers received for reading before his Section in accordance with Rule 30. Papers which are sent direct to the General Secretary by the authors will be forwarded to the President concerned. No abstracts will be printed unless received through the President.

Abstracts should be limited, except in very special cases, to about 200 words. Long abstracts should be reduced by the President. References to literature in abstracts should be avoided as far as possible and when given should conform to the system of abbreviations used by the Association.

The contents of all abstracts should be carefully edited by the President, who has a completely free hand in the matter.

Joint discussions on related papers may be held. Authors of papers should be informed of the time allotted by the President to the reading of their papers. An author contributing more than one paper should be asked to specify which of them he would prefer to read at the meeting.

(6) The President, in consultation with the Local Sectional Secretary, shall make arrangements for such local Sectional excursions as seem desirable. Due notice shall be given to the General Secretaries of all such arrangements.

(7) The President and Recorder should, in consultation with other members of the Sectional Committee, make proposals to the General Secretary regarding the programme of the Section. Such proposals should reach the General Secretary not later than the 1st November, so as to enable the necessary details to be entreed in the programme. General discussions on questions of importance, held either by a single Section or jointly by two or more Sections, should be encouraged. Arrangements for discussions should be made well in advance of the meeting, and abstracts of what the principal participants intend to say should be sent to the General Secretary along with the abstracts of papers. Full reports of such discussions should be sent to the General Secretary within three weeks of the termination of the Session for publication in the Proceedings of the Association.

(8) Early in December copies of a printed form will be issued to Presidents for transmission to members of their Sectional Committee, requesting them to nominate a President for the ensuing year for the consideration of the Sectional Committee in accordance with the last paragraph of Rule 29.

(9) The duties of the Sectional Correspondent and of the Local Sectional Secretary are given in Rule 28.

(10) All persons entitled to be members of the Sectional Committee should enrol themselves without delay as Ordinary Members if not already so enrolled and should inform the General Secretary of the payment of their subscription when accepting the appointment.

(11) The General Secretary should be consulted whenever any question arises not dealt with in these regulations.

II. Local Arrangements.

In accordance with the Rules of the Association, the Local Secretaries and the Local Committee shall jointly, on behalf of and in consultation

with the Executive Committee, make all necessary arrangements for the holding of the Session of the Congress.

The following arrangements have to be made.

A. Accommodation for the Scientific Meetings.

(1) A large hall should be available for (*a*) the President's address on the opening day, and (*b*) for the evening lectures. Both (*a*) and (*b*) are open to the public free of charge. A projection lantern with an operator should be available in this room, and it is a great advantage if loud speakers can be installed.

(2) Rooms for the meetings of the different Sections of the Congress should be provided and suitably furnished. An epidiascope with an operator should be provided in each Sectional room. All the rooms should as far as possible be in close proximity. The following are the Sections of the Congress :—

Mathematics and Physics, Chemistry, Geology and Geography, Botany, Zoology, Anthropology, Agriculture, Medical and Veterinary Research, Physiology and Psychology.

(3) A Reception room should be provided in which Members can get information, write letters, etc. The Local Secretaries' Office should be as near as possible to this room. An arrangement should be made with the Postmaster General to have a temporary Post Office in this room and for all letters addressed to members c/o The Indian Science Congress to be delivered here. The Indian Science Congress Post Office should be situated as near as possible to the Reception room.

(4) A room near the Reception room should be set apart for the General Secretaries' office, which will be opened therein from the 31st December.

(5) Provision should be made for lunch in European and Indian styles at moderate charges near the Reception room.

B. Accommodation for Visiting Members.

The Local Secretaries should send out, not later than the end of November, a printed circular to all Members enrolled, asking them if they desire that accommodation should be arranged for them. It is desirable, as far as possible, to provide private hospitality for the President, Sectional Presidents, and Officers of the Congress. In this circular information should be given regarding the types of accommodation available, with the charges, and the nature of the climate during the Session. The Local Secretaries will receive periodically from the Managing Secretary lists of Members enrolled at headquarters.

C. Programme of the Meeting.

(1) The Sections of the Congress meet daily in the mornings generally from 9-30 A.M. Symposia or joint discussions will be held either in the morning, or from 2 P.M.

(2) Public lectures are arranged by the Executive Committee, and are given at 6 P.M. or 6-30 P.M.

(3) A printed guide with a map of the locality in which the Congress is held should be prepared for distribution to Members on the opening day. Only Ordinary and Full Session Members are entitled to the Guide Book free of cost. A small charge not exceeding Re. 1 (to be fixed by the Local Committee) may be made to other Members desiring to have a copy. The Guide Book should contain a summary of information concerning the scientific and educational activities and a short history of the locality, in addition to general information likely to be of use to visitors.

(4) Arrangements should be made for giving due publicity to the activities of the Congress, both before and during the meeting.

(5) A list of Members with their local addresses where known should be printed and distributed on the opening day. A supplementary list should be typed and posted in the Reception room and maintained up to date. The Local Secretaries shall arrange for this.

(6) A provisional programme of social engagements should be drawn up by the Local Secretaries and sent to the General Secretary by the 25th November. It is essential that this be sent in time, as it has to be printed and distributed with the abstracts by the first week in December.

The General Secretary will make arrangements for printing the programme drafted as above and distributing these to Members enrolled at the time of the distribution of the abstracts.

The final programme shall be printed locally by the Local Committee in time for the opening of the Session.

D. General.

(1) Numbered badges for Members of the Congress will be sent by the Managing Secretary to the Local Secretaries for distribution on the opening day of the meeting. The badges should bear numbers corresponding to the enrolment numbers. There should be additional badges for Officers.

(2) Members of the Local Reception Committee who have made substantial contributions to the funds of the Local Committee may be given complimentary tickets to attend the meetings.

(3) An audited copy of the accounts of the Local Committee should be sent to the General Secretary not later than the 30th April, following the Session, for inclusion in the Proceedings of the Session. It is desirable that the Local Committee should contribute any surplus to the reserve fund of the Association.

(4) Twelve copies each of all local publications connected with the Congress (guide book, final programme, notices, cards, etc.) should be sent to the office of the Association for record at the conclusion of the meeting.

(5) Applications for membership will ordinarily be dealt with by the Managing Secretary at the office of the Association up to the 15th December. After that date applications for membership will be forwarded to the Local Secretaries, who will open a separate account for the sale of membership tickets. The amount thus realised, together with unsold tickets, should be forwarded to the Managing Secretary immediately after the close of the Congress.

(Adopted the 5th January, 1937.)

B. ARRANGEMENTS FOR THE CELEBRATION OF THE SILVER JUBILEE OF THE CONGRESS.

THE FOLLOWING REPORT ON THE PROGRESS REGARDING THE CELEBRATION OF THE SILVER JUBILEE OF THE INDIAN SCIENCE CONGRESS ASSOCIATION WAS SUBMITTED TO THE MEMBERS OF THE GENERAL COMMITTEE.

At the last meeting of the General Committee of the Indian Science Congress Association, held at Indore on January 4th, 1936, the following resolutions were passed unanimously :—

(1) Resolved to invite a deputation of scientists from the British Association and elsewhere to meet in Joint Session with the Indian Science Congress Association in celebration of its Silver Jubilee in January, 1938.

(2) Resolved that the Executive Committee, with power to co-opt, be authorised to take the necessary steps in this connection and to report progress to the General Committee in January, 1937.

To give effect to these resolutions the Executive Committee have been actively engaged during the past year, and the following report of the progress that has been made is placed before the Members of the General Committee for their information.

After inviting the Viceroy-elect to become the Patron of the meeting, and obtaining his consent, the most important consideration was the financing of the scheme. It was clear at the outset that at least half a lakh of rupees would have to be raised by the Indian Science Congress Association as its contribution towards the expenses of the delegation, the balance being raised by the British Association. This sum was far beyond the means of our Association, and it was clear that help from outside would be essential. Moreover, until a considerable portion of this amount could be guaranteed, it was not possible to issue a definite invitation to the British Association. In view of the all-India nature of the celebration, and of the great benefits to be derived from the opportunity provided to scientific workers in this country of meeting some of the most eminent scientists from abroad, it was decided to approach the Government of India for financial assistance. At the end of January a detailed letter explaining the position was sent to the Secretary, Department of Education, Health and Lands, and the Government of India were requested to make a contribution. This was followed up by an interview with the Hon'ble Kunwar Sir Jagadish Prasad, at which Prof. S. P. Agharkar and Prof. J. N. Mukherjee represented the Association. Further correspondence took place, and towards the end of May the Government of India decided to make an allocation of Rs. 20,000 in their budget for 1937-38, subject to the vote of the Legislative Assembly. This generous contribution was gratefully accepted, and enabled an invitation to be sent by cable to the British Association. This invitation was accepted by cable.

THE VENUE OF THE MAIN SESSION.

The next step was to decide on the venue of the main session. In April a letter was sent to all Universities asking them : (1) if they were prepared to invite the Congress, and the amount of financial help that they would be able to provide in the event of the invitation being accepted ;

and (2) if, in view of the all-India nature of the celebration, they were prepared to contribute any sum towards the expenses of the celebration in the event of the main meeting not being held at their centre. To this letter the following replies were received :—

Annamalai.—Agreed to donate Rs. 100 unconditionally.

Bombay.—Hoped to raise a total of Rs. 10,000 if the Session be held in the Bombay Presidency, and agreed to donate Rs. 2,000 if held elsewhere.

Benares.—Agreed to contribute Rs. 10,000 if the Session be held in Benares. (This offer was received after the question of the venue had been decided.)

Calcutta.—Agreed to donate Rs. 5,000 if the Session be held in Calcutta, hoping to raise the total sum required with the help of the Congress. They were prepared to make a supplementary contribution and to consider the amount to be contributed in the event of the Session not being held in Calcutta after the place of meeting had been decided.

Madras.—Practically the same as Calcutta.

Mysore.—Agreed to donate Rs. 500 unconditionally.

Of the remaining Universities, Punjab, Lucknow, Aligarh, Allahabad, Rangoon, and Agra replied that they were unable to make any contribution. Dacca, Delhi and Nagpur had the matter still under consideration. (Patna, Osmania and Andhra have not yet replied.)

In view of these replies, it became clear that the financial position would be made easier if the main Session were held at either Bombay, Calcutta or Madras. At the same time, in view of certain advantages that would be obtained if the Session were held in Delhi, the capital of India, that place was given careful consideration along with the other three.

Since the Government of India had made the handsome donation of Rs. 20,000 to the Jubilee funds, the Executive Committee decided to ascertain informally whether the Government of India had any views as to where the main meeting should be held. Consequently in July Prof. S. P. Agharkar, Prof. J. N. Mukherjee and Mr. W. D. West interviewed Sir G. S. Bajpai, Secretary, Department of Education, Health and Lands, and the Private Secretary to H.E. the Viceroy. These interviews helped to clarify the position. As regards the venue, the Government of India had no particular views on the matter, but at the same time it was made clear that they could only participate in the meeting if it were held in Delhi early in December. It was suggested that there might be a ceremonial welcome at Delhi in December, attended by H.E. the Viceroy and Members of the Government of India, and that the main meeting might be held later elsewhere. As regards the convenience of H.E. the Viceroy, it was quite definite that His Excellency would not be able to attend more than one function. That is to say, if His Excellency attended the welcoming function at Delhi, he would not also be able to attend the opening of the main meeting if held elsewhere. It was also made clear that he would in any case be able to attend a function only if held in either Delhi or Calcutta, in the former if held before about the 14th December, and in the latter if held in January.

The Executive Committee carefully considered the suggestion of having a welcoming function in Delhi and the main meeting elsewhere, and came to the conclusion that it would not be altogether satisfactory. It would not be possible to secure the presence of a representative gathering of Indian scientists at the welcoming function in Delhi as most of them would find it difficult to spare the time required for this in addition to attending the main meeting elsewhere, and the Executive Committee preferred that if H.E. the Viceroy were going to attend one function, that function should be the main meeting where a full attendance of the

members of the Congress would be assured. This they felt would be the desire of the majority of the members of the Association on such an occasion. It therefore became clear that the main meeting would have to be held either in Delhi, not later than the middle of December, or in Calcutta in January as the presence of His Excellency was considered desirable.

As regards Delhi, the lack of adequate accommodation for the meeting, which would not in any case be available until after about December 20th; the fact that Delhi lacks the scientific atmosphere that is found in some cities in India, and that it has never had the experience of holding the Congress; and the early date at which the meeting would have to be held if the Government of India were to participate, were all considerations that weighed against the selection of Delhi for the main Session. Subsequent correspondence showed that the delegation could not possibly arrive in India before the third week in December, so that in any case it would not have been possible to hold the main Session in Delhi. As regards Calcutta, its scientific atmosphere; the ease with which accommodation could be arranged for the delegates and members, as also for the meetings; the fact that the office of the Indian Science Congress Association is in Calcutta; and that both the present General Secretaries are resident in Calcutta; and finally, the fact that the British Association had written that 'it would influence favourably a number of distinguished visitors if they could be told definitely that the jubilee will be held in Calcutta', were all weighty considerations that favoured holding the meeting in Calcutta.

The Executive Committee were thus of opinion that if the meeting were held in Calcutta it would have the greatest measure of success. Before coming to a final decision, however, they decided to take the opinion of the Council, and a summary of the relevant facts was circulated to members. The replies that were received were almost unanimously in favour of Calcutta, only two members suggesting two other (different) places. In consequence the Executive Committee decided to accept the invitation of the University of Calcutta to hold the main Session in Calcutta, and informed the British Association accordingly. In view of this decision, His Excellency the Governor of Bengal was invited to become a Patron of the Session, and he has kindly accepted the invitation.

The Executive Committee have requested the University of Bombay to receive the delegation on behalf of the Indian Science Congress Association on their arrival in India. This they have kindly agreed to do, and they have sanctioned an additional sum of Rs. 1,000 for the expenses in this connection.

The Delegation.

As regards the composition of the delegation, the Executive Committee were from the beginning of opinion that the importance of the occasion warranted an invitation being sent to Lord Rutherford, the most distinguished scientist in the British Empire, to preside over the meeting. It must give every member of the Association the greatest satisfaction to learn that he has been able to accept the office.

Regarding the size of the delegation and its financing, it was originally agreed that the number should be about 50, and that the total expenses of the members should if possible be covered (about £150 per member). Since then the British Association have suggested that the number might be increased to 75, and that each delegate should be given £100. To this proposal the Executive Committee have agreed.

Regarding the personnel of the delegation, it had been arranged that the Indian Science Congress Association should send a list of persons whom it would most like to see invited. In order to draw up this list on as wide a basis as possible, all members of the Sectional Committees were

requested to submit the names of those connected with their own science who they thought should be invited, both from Great Britain and from foreign countries. On receiving this list, the Executive Committee appointed persons to make recommendations, and a final list was approved by the Executive Committee, and forwarded to the British Association.

The British Association have since suggested that the invitations to the delegates from foreign countries might be issued by the Indian Science Congress Association, and this has been agreed to.

Tour Programme.

In view of the all-India nature of the celebration the Executive Committee felt that provision should be made to enable the delegation to visit the more important scientific centres in India. The British Association were accordingly informed of this intention and they suggested that after the main meeting the delegates should form two parties one visiting the centres in Northern India and the other the centres in Southern India. A comprehensive tour programme was drawn up and sent to the British Association. As this would take about seven weeks to carry out, the British Association have suggested that a shorter tour, lasting not more than four weeks would be more acceptable, since most of the delegates were restricted as regards time though a few might be able to stay longer after the Session. A revised programme has, therefore, been drawn up and submitted to the British Association, and it is hoped that it will be possible to inform the General Committee of the details of this programme at their meeting at Hyderabad.

Publications.

As part of the celebration of the Silver Jubilee it has been decided to publish four volumes, and the matter has already been taken in hand. These volumes are as follows :—

I. A History of the Indian Science Congress.

The writing of this volume has been entrusted to Prof. S. P. Agharkar.

II. The Progress of Science in India during the past Twenty-five Years.

This volume will consist of a general introduction and fifteen chapters, each chapter being contributed by a separate authority. Both Sir Martin O. Forster and Sir C. V. Raman were invited to write the introduction and to edit the volume, but owing to the pressure of other work neither was able to accept the invitation. Dr. Baini Prashad has now been invited to undertake the work, and he has accepted. The chapters and their authors are as follows :—

1. Mathematics : Mr. B. M. Sen.
2. Physics : Prof. M. N. Saha.
3. Chemistry : Prof. J. C. Ghosh.
4. Geology and Geography : Dr. A. M. Heron.
5. Botany and Forestry : Prof. S. P. Agharkar and Mr. H. G. Champion.
6. Zoology : Dr. S. L. Hora.
7. Medicine : Sir U. N. Brahmachari.
8. Veterinary Research : Mr. F. Ware.
9. Anthropology : Dr. B. S. Guha.
10. Agriculture : Sir Bryce Burt.
11. Psychology : Dr. G. S. Bose.
12. Physiology : Col. S. L. Bhatia.
13. Archæology : Rai Bahadur K. N. Dikshit.

14. Engineering : Still under consideration.
15. Scientific Education : Dr. W. A. Jenkins.

In each subject the contributors have been authorised to invite help from specialists in particular branches.

III. An Outline of the Field Sciences of India.

The object of this volume is to enable those attending excursions to appreciate what they are seeing in relation to the rest of India. Such a volume would also form a valuable summary for scientists in India who wished to have an outline of these sciences. Dr. S. L. Hora has been invited to edit the volume, and he has accepted the invitation. The contents of the volume and the various contributors are as follows :—

1. An Outline of the Geology of India : Mr. D. N. Wadia.
2. The Vegetation of India : Mr. C. C. Calder.
3. Aspects of the Indian Fauna : Dr. H. S. Rao.
4. The Climates of India : Dr. C. W. B. Normand (provisional).
5. An Outline of the Agriculture of India : Sir Bryce C. Burt.
6. The Oceans around India : Col. R. B. S. Sewell (provisional).
7. Waterways of India : (Still under consideration).
8. An Outline of the Ethnology of India : Dr. B. S. Guha.
9. An Outline of Indian Archæology : Mr. N. G. Majumdar.

IV. Early Indian Science : Prof. M. N. Saha (provisional).

The editorship of this volume has not yet been decided.

FINANCE.

It is now possible to give some idea of the present financial position, from which it will be seen that it is necessary to appeal to members of the Indian Science Congress Association to contribute towards the expenses of the celebration.

The total amount that has to be raised, including the local expenses to be incurred in Calcutta, cannot be less than about Rs. 75,000. The contributions that have so far been definitely promised or received are :—

The Government of India	Rs. 20,000
The University of Calcutta	„ 5,000
The University of Bombay	„ 2,000
The University of Mysore	„ 500
The University of Annamalai	„ 100
The Local Committee of the Indore Session ..	„ 900
	Rs. 28,500

It will thus be seen that about Rs. 46,500 still remains to be raised.

The Executive Committee are of opinion that with the help of the Government of Bengal who have been approached for a grant of Rs. 10,000, with a further contribution from the University of Calcutta, with donations from British and Indian Firms, from Learned Societies and from Members of the Public, it should be possible to raise this sum. They feel, however, that Scientists throughout India will be glad to co-operate in raising the funds, by direct contributions and in other ways. They are therefore issuing an appeal to all scientific workers in India to contribute a sum of at least Rs. 10,000 as they are primarily responsible for the success of the Jubilee celebrations, which will be of such great benefit to Science in India.

C. MEETINGS OF THE GENERAL COMMITTEE, THE EXECUTIVE COMMITTEE AND THE COUNCIL OF THE INDIAN SCIENCE CONGRESS ASSOCIATION.

C.1. *Meetings of the General Committee.*

A meeting of the General Committee of the Congress was held at 2 P.M. on Tuesday, January 5, 1937, in the Address Hall, Osmania University Buildings, Hyderabad, Deccan, with Rao Bahadur T. S. Venkatraman in the chair. The following items of business were transacted :

(1) The minutes of the last meeting held on January 6, 1936, were confirmed.

(2) The proposals made by the Executive Committee regarding revision of Rules 26–31 which had been previously circulated were considerod and the revised rules were adopted.

(3) The Regulations framed by the Executive Committee which had boen previously circulated were considered and adopted.

(4) (*a*) The report on the progress made regarding arrangements for the Jubilee Session to be held in January, 1938, which had been previously circulated, was considered and approved.

(*b*) It was resolved to forward to the British Association additional names suggested for inclusion in the British delegation at the meetings of the Council and of the General Committee held in Hyderabad.

N.B.—These names were in addition to those already sent to the British Association by the Executive Committee.

(5) (i) The President announced the result of the election to the Executive Committee and to the Council as follows :—

Executive Committee.	*Council.*
Prof. B. Sahni.	Prof. J. C. Ghosh.
Prof. S. P. Agharkar.	Lt.-Col. S. L. Bhatia.
Prof. S. S. Bhatnagar.	Dr. A. M. Heron.
Prof. S. N. Bose.	Dr. K. N. Bagchi.
Prof. P. C. Mitter.	Prof. H. K. Mookerjee.

(ii) The President announced that the twenty-fifth (Silver Jubilee) Session of the Congress will be held in Calcutta under the auspices of the University of Calcutta.

The meeting was adjourned to 12, noon, on Wednesday the 6th January, 1937, in the Address Hall, Osmania University Buildings, Hyderabad, Deccan, when the following business was transacted :

(iii) The President announced the names of the President, Sectional Presidents and Recorders of the 25th (Silver Jubilee) Session as follows :

President.

Professor the Right Honourable Lord Rutherford of Nelson.

Section.	*President.*	*Recorder.*
Mathematics and Physics.	Sir C. V. Raman.*	Prof. N. R. Sen.

* Sir C. V. Raman has since declined the appointment and Dr. C. W. B. Normand was appointed President of the Section of Mathematics and Physics.

Sections.	*Presidents.*	*Recorders.*
Chemistry ..	Sir P. C. Ray.*	Dr. Habib Hassan.
Geology and Geography.	Mr. D. N. Wadia.	Prof. L. Rama Rao.
Botany ..	Prof. B. Sahni.	Prof. Saeed-ud-din.
Zoology ..	Prof. G. Matthai.	Dr. G. S. Thapar.
Anthropology ..	Dr. B. S. Guha.	Mr. T. C. Raychoudhuri.
Agriculture ..	Rao Bahadur T. S. Venkatraman.	Dr. A. N. Puri.
Medical and Veterinary Research.	Sir U. N. Brahmachari.	Dr. S. W. Hardikar.
Physiology ..	Brev.-Col. R. N. Chopra.	Dr. S. N. Mathur.
Psychology ..	Dr. G. Bose.	Dr. D. D. Shendarkar.

(6) The following were elected members of the Sectional Committees :

Sections.	*Members.*
Mathematics and Physics ..	1. M. R. Siddiqui, Esq. 2. K. N. Mathur, Esq.
Chemistry	1. Syed Husain, Esq. 2. B. L. Manjunath, Esq.
Geology and Geography	1. C. Mahadevan, Esq. 2. P. K. Ghosh, Esq.
Botany	1. Y. Bharadwaja, Esq. 2. Miss J. Ammal.
Zoology	1. B. K. Das, Esq. 2. H. S. Pruthi, Esq.
Anthropology	1. Brij Mohon Lal, Esq. 2. Prof. M. H. Krishna.
Agriculture	1. C. N. Acharya, Esq. 2. Amir Ali, Esq.
Medical and Veterinary Research ..	1. S. C. A. Datta, Esq. 2. Hyder Ali Khan, Esq.
Physiology	1. S. A. Rahman, Esq. 2. A. Subba Rao, Esq.
Psychology	1. S. C. Chatterji, Esq. 2. W. Burridge, Esq.

(7) The following resolution adopted by the Executive Committee on January 6, 1937, was approved by the General Committee :

> 'that in view of the special importance of the next Session and the larger number of papers and variety of topics that would be under discussion, the Executive Committee considers that in order to facilitate the conduct of the scientific business of the Sections it may be found necessary to split certain Sections in consultation with the Sectional Committees, and that the General Committee be informed accordingly.'

(8) Telegrams and letters regretting inability to attend and wishing the Session a success were recorded.

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* Sir P. C. Ray has since declined the appointment on grounds of health and Prof. S. S. Bhatnagar was appointed President of the Section of Chemistry.

(9) The following votes of thanks and congratulatory messages were adopted with acclamation :

(*a*) A vote of thanks to the Rt. Honourable Sir Akbar Hydari, P.C., Kt., LL.D.

(*b*) The grateful appreciation of and thanks for the Patronage extended to the Session of the Congress by H.E.H. the Nizam of Hyderabad and Berar and for the gracious message of His Exalted Highness to the Congress were recorded.

(*c*) Congratulations to H.E.H. the Nizam of Hyderabad and Berar, on the occasion of the Silver Jubilee of His Exalted Highness' Rule.

(*d*) A vote of thanks to the Government of H.E.H. the Nizam of Hyderabad and Berar.

(*e*) A vote of thanks to the Chairman and members of the Reception Committee and to the Local Secretary for their excellent arrangements and generous hospitality.

(*f*) A vote of thanks to the Vice-Chancellor and members of the Osmania University for their kind invitation to hold the Congress.

(*g*) A vote of thanks to the President and the General Secretaries.

C.2. *Meetings of the Executive Committee.*

Sixteen meetings of the Executive Committee were held during 1937. The following are the important items of business transacted :

(1) Formal invitation was issued to the British Association to hold a joint Session in January, 1938, with the Indian Science Congress Association.

(2) Professor Lord Rutherford of Nelson was invited to accept the office of the President of the Twenty-fifth (Silver Jubilee) Session of the Congress and Lady Rutherford was invited to attend the Session.

(3) Arrangements for the Silver Jubilee Session (*vide* Report under B).

(4) Revision of Rules and framing of the first Regulations in the light of the recommendations of the Council and the report of the sub-committee appointed by the latter (*vide* Section C.1).

(5) A grant of Rs. 250 was sanctioned for the year 1937 to the following :

(*a*) Current Science,

(*b*) The Indian Science News Association (Science and Culture).

(6) A sum of Rs. 600 was sanctioned for 1937 as a contribution to the Royal Asiatic Society of Bengal for the work done on account of the Indian Science Congress Association.

(7) It was decided to close the books of the Association on the 30th November in order to enable the Treasurer to submit audited statement of accounts in time for the meeting of the General Committee.

(8) In view of the special circumstances of the Jubilee Session it was decided to fix the 15th of August, 1937, as the last date for submission to the Presidents of the Sections of the abstracts together with papers intended to be read at the 1938 meeting.

C.3. *Meetings of the Council.*

Three meetings of the Council were held.

The following important item of business was transacted :—

The report of the sub-committee appointed by the Council at its meeting on January 2, 1936, and report on possible improvements in the scientific work of the Congress were considered and alterations in Rules and new Regulations were adopted (*vide* Section C.1).

ACCOUNTS.

I.

Accounts of the Indian Science Congress Association for the year ending with 31st December, 1936.

RECEIPTS.	Rs.	A.	P.	EXPENDITURE.	Rs.	A.	P.
To Balance on 1st January, 1936. With Imperial Bank of India—On Current Account	337	13	11	By Printing Charges..	8,417	0	6
,, Central Bank of India Ltd.—On Fixed Deposit ..	19,450	0	0	,, Postage ..	669	8	6
,, Members' Subscriptions ..	7,446	0	0	,, Contingencies ..	331	11	6
,, Life-Membership Fees.. ..	150	0	0	,, Salaries ..	185	0	0
,, Contributions from Bombay University	500	0	0	,, Indexing ..	74	0	0
,, Contributions towards Jubilee Celebrations ..	1,125	0	9	,, Stationery ..	52	13	9
,, Interest on Investments ..	367	7	0	,, Contributions to—			
,, Interest on Fixed Deposit ..	110	2	3	Royal Asiatic Society of Bengal	600	0	0
,, Miscellaneous Receipts ..	16	14	9	Current Science..	500	0	0
				Science and Culture ..	250	0	0
				,, Balance on 31st December, 1936—			
				Investments—4% Loan 1960–70 for Rs.10,000 at Cost	11,416	10	0
				With Imperial Bank of India—On Current Account	6,956	8	8
				In hand—With the General Secretary	50	1	9
TOTAL ..	29,503	6	8	TOTAL ..	29,503	6	8

Examined with the Books and Vouchers and found in accordance therewith.

(*Sd.*) PRICE, WATERHOUSE, PEAT & Co.
Chartered Accountants.
Registered Accountants. } *Auditors.*

CALCUTTA,
4th February, 1937.

S. L. HORA,
Honorary Treasurer.

II.

Indian Science Congress Association, 24th Session, Hyderabad, 1937.

Statement of Accounts of the Local Reception Committee.

Receipts.	O.S. Rs.	A.	P.	Expenditure.	O.S. Rs.	A.	P.
To Amount received from the Government ..	7,000	0	0	By Printing of Guide Book ..	1,199	13	6
„ Subscriptions and donations from the members of the Reception Committee	3,350	0	0	„ Banquet ..	2,181	5	7
„ Interest on current account ..	22	11	7	„ Lodging of delegates in the University Hostels ..	1,460	13	11
„ Rent of Stalls in the Exhibition B.G. Rs.60 ..	68	13	5	„ Boarding of delegates staying in University Hostels B.G. Rs.1,492 ..	1,740	10	8
„ Boarding charges from delegates staying in University Hostels. B.G. Rs.1,492 ..	1,740	10	8	„ At Home ..	510	8	0
				„ Conveyance expenses of excursion parties in the City and Suburbs, etc. ..	1,266	11	11
				„ Volunteers ..	483	8	6
				„ Secretariat Office expenses including salaries of typists and peons, stationery, postage, etc. ..	1,081	9	11
				„ Reception Room ..	36	5	0
				„ Arrangements for Public Lectures ..	267	9	0
				„ Musical Evening and Drama ..	486	3	10
				„ Miscellaneous ..	726	1	9
				„ Balance ..	740	14	1
Total O.S. ..	12,182	3	8	Total O.S. ..	12,182	3	8

B.G. Rs.100=O.S. Rs.116-10-8.

Mahmud Ahmad Khan,
Hon. Treasurer.

M. Qureshi,
Local Secretary.

27*th September*, 1937.

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Date of issue.	Date of issue.	Date of issue.
26.6.43	9-1-62	
23.12.43	19.11.62	
11.9.47	25.6.65	
12.8.48	22.3.66	
[illegible]	11.5.74	
30.8.49	5/5/95	
31.7.50		
6.9.53		
31.7.58		
24.8.57		
19.9.59		
7-11-59		
30.11.66		